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Soil Survey of Iowa, Report No. 81—Marion County Soils

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SOIL SURVEY OF IOWA

MARION COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS

Agronomy Section
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Soil Survey Report No. 81

November, 1941

Ames, Iowa

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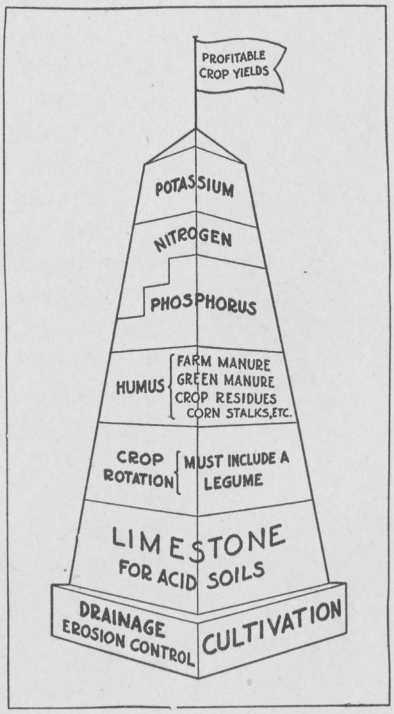
By Roy W. Simonson and T. H. Benton



IOWA AGRICULTURAL
EXPERIMENT STATION

R. E. Buchanan, Director

Ames. Iowa

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MARION COUNTY SOILS[1]

By Roy W. Simonson and T. H. Benton

Marion County is situated in south-central Iowa in the third tier of counties north of the Iowa-Missouri line. Knoxville, the county seat and largest town, is located 38 miles southeast of Des Moines, the state capital, and 51 miles northwest of Ottumwa. With the exception of 55 square miles in the northeastern corner, all of the county lies within the drainage basin of the Des Moines River. The region is a part of a loess-mantled drift plain, once apparently level over extensive areas but now generally rolling because of the dissection of the older land surface by streams. Occasional flat upland divides still mark the level of the former plain.

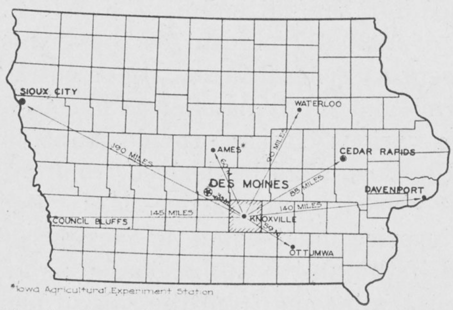

Fig. 1. Map showing location of Marion County.

The total area of Marion County includes 563 square miles or 360,320 acres which are divided into 16 townships. Approximately 95 percent, or 343,235 acres, was occupied by farms in 1938, with 55 percent of the land in crops, 38 percent in pasture and the remainder in miscellaneous uses. The general utilization of the farm land in the county is indicated in table 1.

THE TYPE OF AGRICULTURE IN MARION COUNTY

There were 2,271 farms in Marion County in 1938 as compared to 2,399 in 1930, representing a decrease of 128 operating units. The total acreage in farms did not change appreciably during that interval of time, and the average size of farm increased from 141 to 151 acres. The average size of farm in Marion County is approximately 10 acres below that for the state

TABLE 1. GENERAL UTILIZATION OF FARM LAND IN MARION COUNTY, IOWA, IN 1938.*

Utilization	Acres
All land in farms	343,235
Farmsteads, feedlots, highways	14,517
Cropland, all	185,083
Idle cropland	4,203
Pasture, all kinds	129,787
Plowable pasture	47,959
Woodland pasture	30,970
All other	50,858
Woodlots, used for timber only	3,688
Wasteland, not used for any purpose	9,056

*Data are from the Iowa Yearbook of Agriculture for 1938.

[1]Project 247 of the Iowa Agricultural Experiment Station.
The field work was done by C. L. Orrben, Iowa Agricultural Experiment Station and W. J. Leighty, United States Department of Agriculture. See Soil Survey of Marion County, Iowa, Series 1932, No. 29, published by Bureau of Chemistry and Soils.

[2]Data are from Iowa Yearbooks of Agriculture for 1938 and 1930. All data in this section of the report are from the Iowa Yearbook of Agriculture unless otherwise noted.

as a whole at the present time. In 1938 slightly more than half of the farms in Marion County were operated by tenants and a little less than half, approximately 47 percent by owners.

The predominant type of farming in the county is a combined grain-livestock system, in which the crops grown are fed to livestock on the farm. Small quantities of grains are sold in many of the years, but as large or larger amounts are commonly purchased for the fattening of livestock. According to the United States census of 1930, 67 percent of the farms were classed as animal specialty, 17 percent as general farms, 6 percent as cash grain farms, 1 percent as dairy farms and the remainder as unclassified minor types. The definition of the various classes provides that 40 percent or more of the total income of the farm shall be derived from one particular enterprise before the unit is placed in any given class. For example, income from the livestock enterprise must equal 40 percent or more of the total value of products sold if the unit is to be classed as an animal specialty farm. On general farms the income from the sale of one product or closely related group of products amounts to less than 40 percent of the total income.

The sale of beef cattle and hogs provides the chief source of income on most of the farms in Marion County, but the sale of grain crops, dairy products, poultry and eggs provides important supplementary sources of income. In the more rolling and hilly portions of the county, a considerable number of sheep are raised on pasture and then fattened for market. Feeder cattle and lambs from the western ranges are shipped into the county by a number of farmers who finish the stock before shipping to Chicago or nearer points such as Des Moines and Ottumwa.

Corn, oats and hay are the three principal crops grown in the area. They are used almost entirely as feed for livestock on the farm where grown, but small amounts of each crop are sometimes offered for sale in the county. The production of wheat, minor for the county as a whole, is important to the agriculture in the floodplains of the Des Moines and Skunk Rivers.

CROPS GROWN IN MARION COUNTY

The general farm crops produced in Marion County in the order of decreasing acreage are corn, oats, clover-timothy hay, soybean hay, wheat and alfalfa. Smaller acreages are also devoted to crops such as barley, rye, clover seed, soybeans for grain and sweet clover. The total acreage, average acre-yields and total production of the different crops in the county in 1938 are given in table 2.

From the standpoint of acreage and total production, corn is the most important crop in the agriculture of Marion County. It was grown on slightly more than one-fourth of the farm land in 1938, and the average acre-yield was 36 bushels. This yield is slightly below the average for the 6-year period of 1928 to 1933 inclusive, when the average for the entire county was 40.1 bushels. Deviations from the average yield of corn may be rather large from one year to another, and deviation from the average

TABLE 2. ACREAGES, PERCENT OF FARM LAND, AND YIELDS OF CROPS GROWN IN MARION COUNTY, IOWA, IN 1938.*

Crop	Acreage	Percent of farm land	Average yield (Bu. or tons)	Total yields (Bu. or tons)
Corn	90,838	26.5	36.0 bu.	3,270,168 bu.
Husked or snapped	85,498	24.9	----	----
Cut for fodder	3,199	.9	----	----
Cut for silage	927	.3	----	----
Hogged down or grazed	1,214	.4	----	----
Oats	45,352	13.2	34.0	1,541,189
Winter wheat	8,843	2.6	16.8	148,746
Spring wheat	92	**	13.5	1,242
Barley	579	.1	24.6	12,776
Rye	509	.1	14.3	7,297
Clover seed	2,234	.6	1.03	2,317
Timothy seed	396	.1	3.41	1,348
Sweet clover, all	1,234	.3	----	----
Seed	258	.1	2.6	671
Soybeans for seed	1,514	.3	19.1	28,859
Hay, all kinds	32,575	9.5	1.3 tons	42,295 tons
Clover and timothy	12,305	3.6	1.13	13,905
Alfalfa	6,161	1.8	2.20	13,554
Soybean hay	11,996	3.5	1.05	12,596
All other	2,113	.6	1.06	2,240
Crops not listed	977	.3	----	----

*Data from Iowa Yearbook of Agriculture for 1938.
**Less than 0.05 percent of farm land.

for the county in any one year will also be found on individual farms and fields. There is a range of 10 bushels in the average acre-yields for the 10-year period, 1924 to 1933 inclusive, from the high-producing to the low-producing townships within the county. Even larger ranges in acre-yields can be expected from farm to farm or on different parts of single fields which lack uniformity.

Most of the corn crop is husked or snapped for grain, but small acreages are hogged down, cut for silage or cut for fodder. Usually from 90 to 95 percent of the crop is harvested for grain, an additional 3 or 5 percent is cut for fodder, and the remainder is cut for silage or hogged down.

Hybrid corn has in recent years largely replaced open-pollinated varieties. Open-pollinated, yellow strains such as Reid's Yellow Dent or Krug's Yellow Dent were very popular in the region formerly, but only one-third of the corn grown in 1939 was from the open-pollinated seed.

Small acreages of popcorn, sweet corn and sirup sorghums are grown on many of the farms, principally for home use. Limited quantities of each of the crops are sold locally.

Although the total acreage of oats is second only to that of corn, the value of the crop is ordinarily less than that of hay. Oats were grown on 13.2 percent of the total farm land in 1938, and the average yield was 34 bushels per acre. Acre-yields of oats range from 40 to 60 bushels on the better soil types in favorable seasons, but in dry years, especially if hot weather and dry winds occur at the time the small grain is in the milk or dough stage, yields are sharply reduced. In 1935, a dry season, the average acre-yield of oats was 21.9 bushels as compared to the long-time average of 36.3 bushels.

Oats are commonly grown after corn, as part of the rotation or to serve as a nurse crop for seedings of clover or grass. Locally grown strains of Albion (Iowa 103), Richland (Iowa 105), Green Russian and Iowar are the more popular varieties. Oats are usually sown broadcast in corn-stubble ground that has been double disked. Most of the crop is fed on the farm either as whole grain to work animals or as ground feed to hogs or cattle, but small quantities are sold locally.

The acreage of hay, which comprised 9.5 percent of the farm land in 1938, ranked third in area among the various crops. Soybeans and clover-timothy mixtures each made up approximately 40 percent of all land in hay, and alfalfa was grown on most of the remaining acreage. The total acreages of individual hay crops may fluctuate widely over relatively short periods of time, however. Soybean hay, produced on 4,317 acres in 1934, was grown on 11,996 acres in 1938, whereas the acreage of clover-timothy hay increased from 15,784 acres in 1934 to 23,504 acres in 1936 and then declined to 12,305 acres in 1938. The acreage of alfalfa grown each year has tended to increase slowly, ranging upward from 4,111 acres in 1930 to 6,161 acres in 1938. All kinds of hay other than soybean, clover-timothy and alfalfa occupied only 6 percent of the total acreage devoted to hay production in 1938.

The total production of clover-timothy hay in Marion County in 1938 slightly exceeds that of alfalfa which, in turn, was slightly greater than that of soybean hay. Average acre-yields in 1938 were 1.05 tons of soybean hay, 1.13 tons of clover-timothy and 2.20 tons of alfalfa. The yield of soybean hay, although lower than that of clover-timothy mixtures in 1938, is commonly the larger of the two.

Clover-timothy mixtures are generally sown with a small grain nurse crop and left on the land from 1 to 3 years. The clovers often die out after the first season, and the land is then used as timothy meadow. Red clover or clover-timothy mixtures can be grown on many of the soils without the use of lime if the season is favorable, but applications of lime will insure a larger proportion of clover in the stand. Inoculation of the legume seed with suitable cultures of bacteria is always desirable.

Alfalfa is sown with a small grain nurse crop in the same manner as clover-timothy mixtures, but the crop is generally left on the land for a longer period of years. The application of agricultural limestone prior to the sowing of alfalfa is necessary on most of the soils in Marion County. Application should be made according to the lime requirement of the particular area of soil, preferably 1 or 2 years before the crop is to be sown.

Soybeans are more tolerant of acid soil conditions than are alfalfa or red clover, and soybean hay can be grown with a fair degree of success without the use of lime on most of the soils in Marion County. The planting of soybeans should be restricted, however, to smooth uplands, terraces and the higher-lying portions of the floodplains where the land has very little slope, otherwise serious accelerated erosion may follow the growing of the crop. Where soybeans have been grown, the surface layer of the soil is left in a loose, fluffy condition that permits rapid erosion during heavy rains that may come after the harvesting of the beans in the fall and prior to the establishment of another crop the following spring.

Small amounts of grass or legume seed are produced in the county each year, with the acreage of red clover grown for seed ordinarily much larger than that of any of the other legumes or of the grasses. In 1938, red clover seed was harvested from 2,234 acres as compared to 396 acres of timothy for seed and 258 acres of sweet clover for seed.

Crops grown occasionally for hay or for pasture include sweet clover, lespedeza, sudan grass and sorghums. Sweet clover is most commonly grown for pasture or to be plowed under as a green manure crop, and it requires soil conditions similar to those needed by alfalfa. Lespedeza has been used as pasture, particularly in the late summer. Sudan grass and sorghums are grown either to provide supplementary pasture and hay or for use as additional roughage or fodder.

Small-grain crops other than oats are grown only on limited acreages in Marion County. Wheat is usually produced on an area ranging from 6,000 to 10,000 acres, most of the crop being grown in the bottoms of the Des Moines and Skunk Rivers. The crop, most of which is of the Turkey Red variety, is usually sown with a drill in disked land that was in corn the preceding year. Rye and barley were each grown on slightly more than 500 acres in 1938, with average acre-yields of 14.3 and 24.6 bushels, respectively. Rye is generally grown on some of the sandier soil types, and barley is produced as a minor feed crop.

A few fruits and vegetables for home use are produced on many farms, but only small areas are devoted to commercial production. Small fruits such as raspberries, strawberries and blackberries are most commonly grown, although some small apple or pear orchards also exist within the county. The total production of fruits and vegetables does not meet the needs of the local markets.

LIVESTOCK PRODUCTION IN MARION COUNTY

The farm income of Marion County is derived largely from the sale of livestock and livestock products. Small quantities of grain and hay crops are shipped out of the county, but amounts of grain equal to the total production of the area and almost all of the hay are used as feed for animals and poultry. The number of livestock on farms as of Jan. 1, 1939 and poultry on farms in 1934 is given below:[3]

Cattle, all ages	30,696
Cows and heifers milked	10,767
Hogs, all ages	54,529
Sows	18,586
Sheep	32,534
Horses	6,997
Mules	649
Chickens	247,977

The sale of hogs provides the largest immediate source of income on most farms. Hogs are generally raised and fattened on the same farm, although some farmers buy feeders and fatten them for market. Pigs are

[3]Data are from Iowa Yearbook of Agriculture for 1938 except for the number of chickens which is from the federal agricultural census of 1935.

usually farrowed in the spring and kept over the summer and fattened for shipment in the following fall or winter months. Sows which farrowed in the fall of 1938 numbered 4,317 as compared to 14,271 sows bred to farrow in the spring of 1939. Hogs are kept until they reach weights of 250 or 300 pounds before being sold, many of them then being trucked to markets at Des Moines or Ottumwa. Some carloads of hogs, however, are shipped to Chicago markets each year.

There were 30,696 cattle on farms on Jan. 1, 1939, of which slightly more than one-third were cows and heifers kept for milk production. The remaining two-thirds of the cattle in the area are chiefly grades from such beef breeds as Hereford, Shorthorn and Aberdeen Angus. Only a small number of purebred herds is found in the county. The income derived from the sale of beef cattle is lower than that of hogs but higher than that obtained from the sale of other livestock or livestock products. Most of the cattle sold are raised within the county, but some Hereford or Shorthorn feeders are shipped in from Omaha, Kansas City or Des Moines stockyards each year. Feeders are usually bought in the fall and fattened before being sent to market. Cattle are transported by truck to market in Ottumwa or Des Moines or sent by rail to Chicago yards, with most of the stock going to nearby markets.

The production of beef cattle or other livestock which graze on pastures permits the best use of many of the lands in Marion County. At the present time, approximately 38 percent of the land in the county is in pasture, one-third of which is classified as plowable. Plowable pasture totaled 47,959 acres, whereas woodland and other permanent pasture amounted to 81,728 acres. Pastures other than woodland are chiefly bluegrass and furnish good grazing during much of the year. Woodland pastures ordinarily support thinner stands of grass and furnish less grazing.

Dairy farms make up a very small proportion of the total number of farms in Marion County, but the production of milk, cream and butter is a secondary source of income on many farms. Practically all farms produce milk and cream for their own use, and many sell small quantities of cream or butter. Cream is generally sold to local cream-buying stations, several of which are located in every town.

The raising of sheep, although not confined to any particular parts of the county is more generally practiced in the rougher or more rolling sections. The total number of sheep on farms as of Jan. 1, 1939, slightly exceeded that of cattle. Most of these sheep had been raised in the county, but some of them were feeder lambs that had been shipped in to be fattened. Shropshires are perhaps the most popular breed, both in the farm flocks and as feeder lambs.

Small flocks of chickens, ranging from 50 to 150, are kept on most of the farms. Some large flocks of 400 or 500 birds are kept in the region, but these are not common. In addition to the chickens which are raised, many farms also keep flocks of turkeys, ducks or geese.

GEOLOGIC FACTORS AFFECTING SOILS OF MARION COUNTY

A brief discussion of the topography and the nature and origin of the soil parent materials in Marion County should contribute to a better understanding of the soils. The topography consists of rolling or sharply rolling lands with occasional elevated flats or divides that are remnants of an old extensive plain. The more rolling or hilly bodies of land lie adjacent to the larger streams where dissection has been most active, whereas gently rolling areas border the flat divides where stream dissection has been less complete. The soil parent materials consist primarily of three groups of sediments: Loess (deposited by wind), glacial drift (left by ice) and alluvium (deposited by running water). There are, however, numerous small outcroppings of shale or limestone in the county, and a few of these are large enough to have supplied parent materials for soil formation. The loess, drift and alluvium which make up more than 90 percent of the parent materials for the soils of the region seem to have been derived, to a large extent, from local sources. Minor quantities of sediments, such as the granitic boulders and gravels in the drift, were brought in by the glaciers from other regions.

The shales and limestones which now form the bedrock of the area had probably been exposed and weathered rather deeply prior to the glacial period; deeply buried stream valleys filled with glacial drift, indicating a long interval of weathering, are known to exist in the county. The weathering of the sedimentary rocks prior to the glacial invasions resulted in the formation of a deep regolith[4] that supplied the material picked up by the ice when it moved into the county.

When glaciers first invaded the region, the loose materials of the regolith were picked up in part by the advancing ice, mixed with smaller quantities of rock debris brought from northern regions, and re-deposited as the ice melted. Granite boulders and gravels now found in the county appear to have originated as far away as northern Minnesota or western Ontario, but the sands, silts and clays which comprise the large bulk of the glacial deposits seem to have been moved but short distances. Most of the drift consists of unsorted debris left in place as the ice melted (glacial till), but there are occasional deposits of gravel, sand or silt which apparently were formed by outflowing waters from melting ice (outwash deposits). Two separate glacial invasions have reached Marion County, both of them a long time ago. The earlier or Nebraskan ice sheet touched only a small part of the county, whereas the later or Kansan glacier covered the entire area. The drift left by both of the ice sheets has been thoroughly weathered since deposition so that no distinction can now be made between the soils formed from Nebraskan or Kansan tills.

After the region had been glaciated, perhaps during the time of melting of the ice, a deposit of loess (wind-blown silts and clays) was laid down over the surface of the till plain. It is believed that fine-textured materials deposited in the river floodplains by waters flowing out from the melt-

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[6]Relief is the maximum difference in elevation within a given area as, for example, within 1 spuare mile or disintegrated rock debris and the soil.

ing ice in the summertime gradually dried in the fall and then were blown out over the uplands. Part of the loess was perhaps derived from the floodplains of streams such as the Des Moines River, and another part seems to have come from regions to the west. All of the loess was apparently deposited slowly over long intervals of time.

SOIL PARENT MATERIALS

As already has been indicated, loess, glacial till and alluvium comprise the parent materials for nearly all of the soils of Marion County. The covering of loess or till is thin on steep valley slopes, however, and in such locations the bedrock has contributed some of the material from which the soil was formed. This is particularly true of the soil which has been mapped as Clinton silt loam, shallow phase. The latter soil is found along the more deeply entrenched streams of the county where shale or interbedded shale and limestones outcrop along the valley slopes. A thin covering of loess is present on many of these valley slopes, where it has been mixed with some disintegrated sedimentary rock. Total acreage in which the bedrock has contributed directly to the soil parent material is less than one-tenth of the county area.

The loess which covers most of the upland in Marion County—58.8 percent of the total area—ranges in thickness from a few inches on some of the steeper slopes to as much as 17 feet in places.[5] The more commonly occurring depths range from 70 to 80 inches and are found in the rolling uplands occupied by Tama and Clinton soils. The maximum thickness of the loess deposit occurs in the flat uplands that are remnants of the former plain, whereas wind-blown materials are often absent from the steeper slopes along the larger streams. Over most of the area of its occurrence, the loess has been leached of its lime carbonate, indicating an advanced stage in the weathering processes. Colors of the deposits range from dull gray to light grayish-yellow with occasional rust-brown mottling, particularly in the dull gray loess. A few mottlings can be seen in the lower portions of the lighter-colored loess deposits, but they are seldom numerous. The texture of the loess ranges from a silt loam to a silty clay, with silty clay loam occurring most widely. Occasionally the loess may contain some fine sand, but boulders or gravel are not present. Six soil series in Marion County, the Tama, Muscatine, Grundy, Putnam, Clinton and Weller have been developed from loess.

Kansan till, unsorted glacial debris, is exposed on slopes in the sharply rolling and hilly portions of the county. The till consists of a mixture of particles that range in size from very fine clays to large boulders. Coarse sand and small gravels are of common occurrence in the till over the entire county, and boulders of various sizes are found both on the surface and within the body of the till. Textures range from sands to clays, but the most commonly occurring one is that of clay loam. Colors of the till deposits are usually dull grayish-yellow or yellowish-brown, but they may vary from blue-gray to reddish-brown. Where it occurs on smooth or gently rolling topography, the till has been leached of lime carbonate to

[5]Miller, L. B. Geology of Marion County. Iowa Geol. Survey Ann. Report 11:163-166. 1901.

great depth, but along the streams where the relief[6] is greater, carbonates may sometimes be found at or very near the surface. These carbonates commonly occur in the form of soft concretions or splotches within the till. Because of the leaching and general removal of carbonates, the till is commonly acid, but it is distinctly alkaline on the steeper slopes where the lime carbonate concretions occur near the surface.

One modification of the till which can be found occasionally in Marion County is the dull gray gumbotil, a material apparently formed by extreme weathering of the till while the land surface was relatively flat prior to the development of an adequate drainage system. The gumbotil is extremely heavy in texture, acid in reaction, and has been little changed by the processes of soil formation where it does outcrop at the surface. Areas of gumbotil generally are found on slopes immediately below the loess and are known in some parts of southern Iowa as "push" soils.

Most of the Kansan till which has been exposed in Marion County exists in the form of bands along the slopes, lying between the loess on the higher land and the alluvium in the stream valleys. Two soil series, the Lindley and Shelby, have been formed from till materials, and together they occupy 20.3 percent of the county area.

Floodplains and terraces composed of alluvial materials occur in the river valleys, along the smaller streams, and along many of the drainageways in the upland. The floodplains or overflow lands make up 17.7 percent of the area of Marion County, whereas the terraces occupy 3.2 percent. The alluvial materials in the floodplains most commonly consist of silts and clays, although sands and gravels may be found at times. These materials have been sorted by the action of running water so that sediments within a single layer are all nearly alike as to size; for example, a layer may contain silt and some clay or sand and some silt, but it will not contain a mixture of clay and gravel. Interbedding or the occurrence of alternate layers of sand and silt or silt and clay is common, however, both in terrace and in floodplain deposits.

In the valleys of the smaller streams, the alluvium has been derived from local materials—sediments that were washed down from the loess and glacial till of the uplands. In the valleys of the Des Moines and Skunk Rivers, however, only part of the alluvium is of local origin, and part of it has come from lands which lie in the upper portions of the drainage basins. The Wabash, Cass and Genesee series are young soils which are in process of development from the alluvim within the floodplains, whereas deposits which were very recently laid down are mapped as Riverwash.

Terraces or second bottoms, as they are often known, occupy slightly more elevated positions than do the floodplains, but they consist of similar sediments. The terrace deposits in Marion County include some that are rather fine in texture, from which soils of the Bremer, Waukesha, Jackson and Chariton series have been formed, and some that are coarse on which O'Neill soils occur.

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[6]Relief is the maximum difference in elevation within a given area as, for example, within 1 square mile or within a township.

TOPOGRAPHY AND DRAINAGE

The topography in Marion County ranges from flat or very nearly flat in the bottomlands and on some of the undissected upland divides to sharply rolling or hilly in the strips of land adjoining the valleys of the larger streams. Areas with intermediate relief occur around the edges of the flat uplands and in regions where stream dissection has been active but is not well advanced. Natural drainage of the region is provided by the Des Moines River and its tributary streams over all of the county except the northeast corner. The drainage is adequate to excessive over much of the upland but is restricted in parts of the bottomlands and on some of the upland divides.

The upland flats, comprising about one-tenth of the total area of the county, appear to be remnants of a former plain which now exists only in the form of isolated interstream divides. Most of the flat uplands occur at approximately the same elevation, with a gradual decrease toward the east. They occur in all parts of the county except in the immediate borders of the river valleys but are most numerous in the western and southern portions. Occurring in a region where the network of drainageways has penetrated to all parts of the upland, the present divides are relatively narrow, irregularly outlined areas which often extend for a number of miles. Very few of the flat divides are more than a mile wide, many more are less than one-fourth mile in width, and perhaps the most common width would fall between one-fourth and one-half mile.

By far the largest portion, approximately 70 percent, of the land in Marion County has a rolling or hilly topography. Gently rolling or rolling areas make up the bulk of the upland and can be found in all portions of the county. The gently rolling topography occupies positions intermediate between the flat ridge crests and the steep or hilly terrain that borders the larger streams. Steep or hilly lands are found immediately adjacent to the floodplains of large streams and rivers, particularly where smaller drainageways have cut deep valleys in order to reach the level of the larger stream. Outcrops of sedimentary rock occur in the rougher lands along the Des Moines and Skunk Rivers and along the larger creeks, and seams of coal are exposed in a number of places.

The floodplains and terraces of streams make up a larger acreage of the smooth or gently sloping land in Marion County than do the flat upland divides. Approximately one-fifth of the land area consists of bottomlands and terraces, either along the Des Moines and Skunk Rivers or along smaller streams. The valley of the Des Moines River, which enters near the northwest corner of the county and crosses toward the southeast, ranges in width from 1 or 1½ miles to as much as 3 miles. The valley of the Skunk River, crossing the north half of the northeast corner township, is of approximately the same width. The larger part of the valley in each instance consists of floodplain rather than terrace; the entire acreage of terraces in the county is only one-sixth as large as that of bottomlands. Bottomlands along streams such as Whitebreast, English and Cedar Creeks also range up to a mile in width at some places, and smaller strips of bottomlands will be found along many of the drainageways which extend into the upland.

Drainage waters from all of Marion County, with the exception of some 55 square miles in the northeast corner, find their way into streams that flow into the Des Moines River. The northeast corner of the county is drained by tributaries of the Skunk River, which flows across the corner township and approximately parallels the course of the Des Moines River. Although a number of small streams empty directly into the Des Moines River itself, three of its tributaries drain large portions of Marion County. All three of these streams, Whitebreast, English and Cedar Creeks, rise in counties to the south and southwest and then cross the southern part of Marion County in a northeasterly direction. Smaller tributary drainageways then branch out from these larger creeks into all parts of the upland which lie along their courses. The branching pattern of streams and drainageways which carry away runoff waters in Marion County is shown in fig. 2.

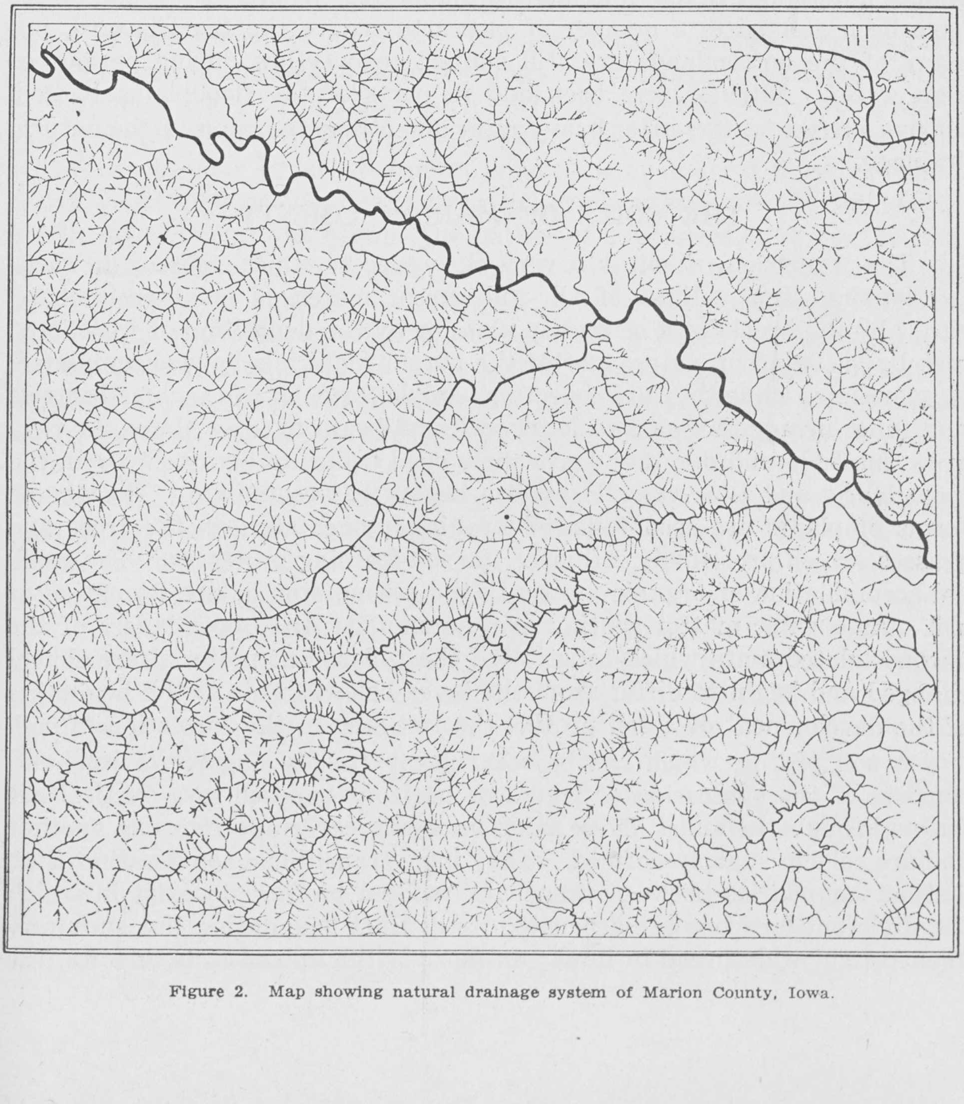


Figure 2. Map showing natural drainage system of Marion County, Iowa.

The gradient of the various streams ranges from an average of approximately 2 feet per mile in the airline distance across the county along the course of the Des Moines River to as much as 10 or 15 percent (10 or 15 feet vertical fall per 100 feet horizontally) along some of the intermittent drains that reach back into the upland. All of the streams are gradually deepening their channels and slowly advancing into the uplands.

Natural drainage is adequate on most of the soils in the county from the standpoint of crop production on these soils. Three soil types on the flat uplands, the Grundy silt loam, Muscatine silt loam and Putnam silt loam; three soils on terraces, Bremer silt loam, Bremer silty clay loam and Chariton silt loam; and Wabash silty clay loam in the bottomlands have restricted natural drainage. Artificial improvement of drainage is feasible on all of these soils except the Putnam silt loam and Chariton silt loam plus a number of areas of Wabash silty clay loam which occupy depressed sites in the stream bottoms. Drainage problems will be discussed somewhat more in detail, however, in the section on management practices.

There is some danger from overflow along the valleys of the Des Moines and Skunk Rivers and along a number of the creeks. Small levees have been erected in a number of places to reduce the flood hazard, but many of the bottomlands are still subject to overflow during periods of high water. Ditches have been dug in parts of the floodplains to help remove surface waters after heavy rains and otherwise improve the natural drainage.

THE SOILS OF MARION COUNTY

The formation of soil is a very slow process which goes on in three overlapping steps. First of all, soil parent materials must accumulate, either by the breakdown of rock in place or by the deposition of weathered rock by ice, wind or water. After the parent materials have accumulated, or sometimes while they are collecting, simple forms of life such as bacteria and fungi invade the mass of loose rock and begin to grow there. As they grow, multiply and die, they leave their dead bodies to decay slowly in the rock debris and thus organic matter begins to accumulate. The simple forms of plants are soon followed by higher ones such as the trees and grasses, which profoundly influence the soil-forming processes. The gradual accumulation of organic matter is the second step in the formation of soil. As organic matter continues to accumulate, the upper layers of the unconsolidated mass which constituted the soil parent material are slowly changed and begin to differ from the layer below. This is the beginning of the development of a soil profile, the last step in the formation of soil.

A soil profile, which can be seen in any freshly dug pit or road-cut, consists of the succession of layers or horizons exposed in a vertical cut down through the soil. These horizons or layers grade into one another and are seldom sharply defined. They have transitional zones rather than distinct boundaries between them. Occasional profiles do exist in which the different horizons are separated by distinct boundaries, but such profiles are not widespread in Iowa. In most of the upland soils of Iowa, the profile consists of a rather deep, dark-colored horizon at the surface grading through lighter-colored layers into the parent material beneath.

The first step in soil formation, namely the accumulation of parent materials, is a geological rather than soil-forming process. The disintegration of rock and the transportation of the weathered materials are forerunners of soil formation; such processes do not in themselves give rise to soils. Occasionally, the second and third steps in soil formation will begin before the rock is fully broken down and soon give rise to a very young soil. In a large area such as the state of Iowa, soils can be found in all the different stages of formation, ranging from sandbars recently laid down by the Mississippi River to soils with very distinct profiles such as Edina silt loam found in southern Iowa. Most of the soils used for crop production in Iowa have advanced beyond the stage of accumulation of soil parent materials and have reached the third step in soil formation—the development of the profile.

Although the steps in the formation of soil are the same, the processes operating in each of the three steps differ very much from place to place. The accumulation of soil parent material by deposition from running water leaves as well-sorted, often fine-textured sediment, whereas the materials left by ice are unsorted and include particles that range from huge boulders to the finest clay. The soils which form on each of these two types of parent materials will differ in a number of important respects. Similarly, soils formed under different climatic conditions or under different types of native vegetation on identical parent materials will not be the same once profile development has begun. The nature of a soil depends upon the combined influences of climate, native vegetation, parent materials, relief and age (the interval during which the soil has been developing). Regional differences in the nature of soils, as between Iowa and Michigan, for instance, are commonly due to influences of climate and native vegetation. Local differences within smaller areas are most often due to parent materials or to relief, but they are sometimes due to differences in native vegetation.

Nearly three-fourths of Marion County is occupied by dark-colored soils of the Prairie and associated poorly drained groups. The dark colors of the surface layers are due to high contents of organic matter which accumulated during the development of the soils under tall grass vegetation. These dark-colored upper horizons are distinctive features of the Prairie soils, a group which occupies extensive areas in Iowa and neighboring states. Prairie soils and others which are Prairie-like in nature occur in the uplands, on the terraces and in the bottomlands of Marion County. The Prairie soils, including series such as the Tama and Shelby, are well drained, whereas those soils that are Prairie-like include the Muscatine, Grundy, Bremer and other series formed under conditions of imperfect natural drainage.

In addition to the dark-colored soils which occupy the larger part of Marion County, there are a number of light-colored soil types which were formed under forest vegetation. These light-colored soils, chiefly members of the Gray-Brown Podzolic group, are confined largely to upland and terrace areas which were occupied by trees, but one series, the Genesee, occurs in the bottomlands. Genesee soils are found under conditions of imperfect drainage, but they are relatively young and have not as yet developed the dark-colored surface horizons commonly associated with restricted drainage. The light-colored soils of the uplands and terraces have been formed from parent materials similar to those beneath the Prairie soil types but differ from them because of the differences in native vegetation.

The acreage and proportionate extent of the various individual soil types mapped in Marion County are given in table 3.

Twenty-six soil types and phases in 16 different series and one miscellaneous land type, Riverwash, were mapped in Marion County. For purposes of discussion, these individual mapping units have been classified into four groups on the basis of a few properties such as the color of the profile and the conditions of natural drainage. The features which are common to all soil types and phases within a single group are discussed, and the differences between them are also indicated. Each soil type and phase and the one miscellaneous land type are then described individually as to occurrence, extent, profile characteristics, general utilization and special management problems. General management practices to maintain fertility and improve the productivity of the soils are discussed in the latter part of the report.

TABLE 3—ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS MAPPED IN MARION COUNTY, IOWA

Type of soil	Acres	Per-cent	Type of soil	Acres	Per-cent
Grundy silt loam	23,552	6.5	Putnam silt loam	512	0.1
Muscatine silt loam	16,960	4.7	Weller silt loam	3,840	1.1
Muscatine silt loam, slope phase	23,552	6.5	Lindley silt loam	23,744	6.6
Tama silt loam	76,928	21.4	Jackson silt loam	640	.2
Tama fine sandy loam	1,088	.3	Wabash silt loam	39,040	10.8
Shelby silt loam	49,536	13.7	Wabash silt loam, colluvial phase	192	.1
Waukesha silt loam	2,624	.7	Wabash silty clay loam	15,360	4.3
Bremer silt loam	5,568	1.5	Wabash loam	896	.2
Bremer silty clay loam	1,152	.3	Cass fine sandy loam	3,520	.2
Chariton silt loam	1,344	.4	Cass silty clay loam	640	1.0
O'Neill fine sandy loam	384	.1	Genesee fine sandy loam	576	.2
Clinton silt loam	41,088	11.4	Genesee silt loam	320	.1
Clinton silt loam shallow phase	24,192	6.7	Riverwash	2,752	.8
Clinton fine sandy loam	320	.1	Total	360,320	

DARK-COLORED SOILS WITH FREE NATURAL DRAINAGE

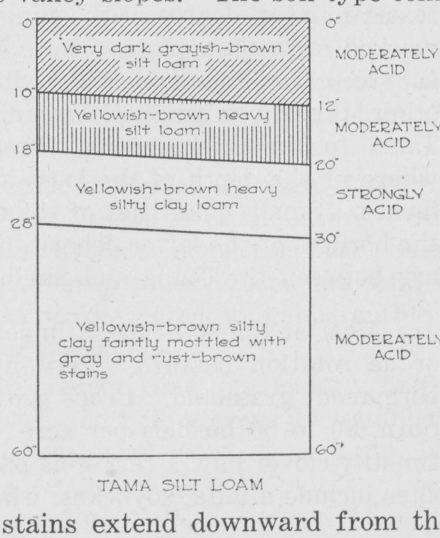
The dark-colored soils with free natural drainage comprise 42.7 percent of the county area and are all members of the Prairie group. Five soil types and one phase, representing five soil series, have been included in the group. All of these soils have profiles consisting of friable, dark-colored surface horizons that grade through transitional, lighter-colored layers into the soil parent material, whether that be loess, glacial till or alluvium.

Three of the soil types, Tama silt loam, Tama fine sandy loam and Muscatine silt loam, slope phase, have been developed from loess on gently sloping or rolling uplands. The Tama soils commonly occur in regions with gently rolling to rolling topography, whereas the Muscatine silt loam, slope phase, is found on gently sloping or rolling sites bordering Grundy silt loam. A fourth soil type, Shelby silt loam, also occurs in the upland but has been formed from glacial till that outcrops on slopes below the Tama or Muscatine soils. The two other types in the well-drained, dark-colored group are Waukesha silt loam and O'Neill fine sandy loam, both of which occupy terraces with gently sloping surfaces sometimes marked by slight irregularities. Waukesha silt loam has been formed from silty alluvium, whereas O'Neill fine sandy loam has been developed from sandier materials overlying gravel beds at depths of 3 or 4 feet.

Differences in the profile characteristics of the soils of the well-drained, dark-colored group are due to the different types of parent materials from which they were formed or to variations in the topography on which they occur. Shelby silt loam occurs on glacial till where relief is rather marked, Tama soils have been formed from wind-blown materials in gently rolling landscapes, and the Waukesha and O'Neill soils were developed from alluvium in level or gently sloping terraces.

Tama Silt Loam (Ts) (120)

Tama silt loam, a Prairie soil formed from loess, occupies the largest acreage of any of the soil types of Marion County. It is found in rolling upland areas below Muscatine silt loam on the flat interstream divides and above the Shelby soils on the steeper stream valley slopes. Where drainageways have penetrated all parts of the upland and have dissected the former level plain but have not exposed glacial materials, Tama soils occupy all of the upland above the steep valley slopes. The soil type commonly occurs in the form of rather large, irregular bodies broken by strips of Shelby along the deeper drains or by winding areas of Muscatine on flat uplands. Most of the total area of Tama silt loam, amounting to 21.4 percent of the county, is distributed through the northern and western portions of the region, though there are some small bodies of the soil type in the southern townships.



TAMA SILT LOAM

The profile of Tama silt loam consists of a mellow, very dark grayish-brown silt loam to depths of 10 or 12 inches, where it grades into yellowish-brown, heavy silt loam. Streaks and stains extend downward from the darker-colored surface horizons into the second layer to depths of 18 to 20 inches, below which the soil materials are pale yellowish-brown silty clay loam. There is little change in the lower horizons of the profile with regard to texture or structure, but faint gray mottlings and occasional reddish-brown stains begin to appear at depths of 24 inches and are numerous below 36 inches. Occasional soft iron concretions are also present in the lower horizons of the soil profile.

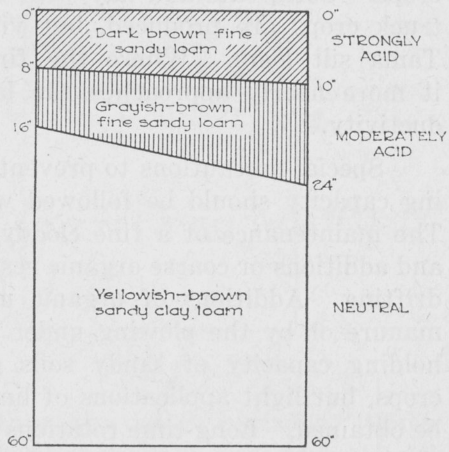
Variations from the profile of Tama silt loam described in the preceding paragraph are rather common. The depth of the surface layer may range anywhere from 6 to 15 inches, depending upon the slope and the degree of erosion. In general the profiles with shallower surface horizons are found on the steeper slopes and on the crests of narrow ridges where thinner, dark-colored horizons developed originally and where the soil is more susceptible to accelerated erosion when it is farmed. On some of the steepest slopes occupied by the soil type, the yellowish-brown horizon is now exposed directly at the surface, apparently by erosion of the surface layer. The deepest surface layers are found in those profiles which occur on lower slopes where local wash has accumulated on the surface of the Tama soil. The thickness of the uppermost horizon in such locations may range up to 18 or 20 inches. Variations in the color and thickness of the surface layers and in the color and texture of the deeper horizons of the profile are found wherever the Tama silt loam merges with other types, such as the Clinton, Muscatine or Shelby soils. Where Tama silt loam joins the lighter-colored Clinton silt loam, there is a gradual change in the color of the surface layer in passing from the main portion of the Tama to that of Clinton silt loam. Part of the transition zone will be included within areas mapped as Tama silt loam and part within the area mapped as Clinton silt loam. Where bodies of Tama silt loam adjoin either the Muscatine or Grundy soils, the deeper horizons of the soil are distinctly heavier in texture and more highly mottled than in the profile described. The change in texture and in degree of mottling in the lower part of the profile is most marked in the few places where Tama silt loam borders areas of Grundy. On steep or rolling sites where Shelby and Tama soils lie adjacent to each other, there is a gradual thinning of the loess and a gradation from the Tama to the Shelby soils. In such areas Tama silt loam is mapped wherever the depth of the loess above the glacial till equals or exceeds 30 inches. Small quantities of till are sometimes mixed with the loess along the borders of the latter deposit, making it difficult to establish the boundary between the Tama and Shelby soils.

Most of the soil type is under cultivation, being used either for crops or as rotation pasture. Very little of the total acreage is devoted to permanent grassland. Crops grown and the range in yields obtained are: Corn, 30 to 50 bushels per acre; oats, 30 to 40 bushels per acre, and timothy-clover hay, 1 to 2 tons per acre. Crops produced on smaller acreages include alfalfa, soybeans, wheat and a number of others.

Management practices desirable for the improvement of productivity of Tama silt loam include the addition of organic matter, applications of fertilizers, the use of lime and precautions to prevent erosion on steep slopes. Lime is ordinarily necessary for the successful production of legumes such as alfalfa or sweet clover, and these crops are also especially benefited by applications of phosphate fertilizers.

Tama Fine Sandy Loam (Tf) (259)

There are only three areas of Tama fine sandy loam in Marion County, the largest of which lies east of the Skunk River in the northeastern township. The two other areas, which bring the total extent of the soil type to a little less than 2 square miles, are located immediately south of the Des Moines River valley in the north-central part of the county. The fine sandy loam areas occupy sharply rolling uplands adjacent to the river valleys and merge with the Tama silt loam that makes up the bulk of the upland farther from the river.



TAMA FINE SANDY LOAM

The most widely occurring profile of Tama fine sandy loam includes a surface layer, 8 to 10 inches deep, of dark brown or dark grayish-brown fine sandy loam and a transitional lighter-colored sandy loam horizon overlying yellowish-brown sandy clay loam. Variations from the predominant profile are rather common, however, because of the variability in the thickness of the sandy deposit. The depth of the layer of sand over loess materials ranges from a matter of inches to as much as 18 feet. On the low ridges and knolls where the sand is deepest, the surface layer of the soil is light brown, and the lower part of the profile consists of yellowish-brown sand rather than a sandy clay loam. Where the sand is quite thin, the soil profile is very similar to that of the Tama silt loam, in contrast to the rather undeveloped profile on thick deposits of sandy sediments.

The sandy deposits apparently have been formed through the movement of materials by wind action from the floodplains of the rivers. Outcrops of loosely cemented sandstone generally occur along the river valleys near bodies of Tama fine sandy loam and seem to have been the original source of the sand, which, after the rocks disintegrated, was apparently reworked by water and then blown out over the upland.

The sand blows occasionally at the present time, particularly in the spring as it dries after having been plowed and before crops are established. Drifting is generally restricted to local movement of material, but the blowing sand may damage crops, especially young corn plants. Local spots of Tama fine sandy loam which are light-colored because of a low content of organic matter in the surface horizon drift very readily and should be handled with special care.

In addition to the hazard of soil blowing in the springtime, there is an additional danger of damage to crops by drouth during all but the most favorable growing seasons. Most of the areas of Tama fine sandy loam are moderately to sharply rolling in topography which, coupled with the high permeability of the soil, provides excessive natural drainage. Though the permeability of sandy soil is high, the water-retaining capacity is low, and a large portion of the moisture absorbed by the soil is not stored for use by growing plants.

The difficulties which accompany cultivation of Tama fine sandy loam have not prevented the use of a large part of the total acreage for crops. Corn, oats and hay with some small patches of melons and other truck crops are produced, but yields obtained are much lower than on Tama silt loam. Where the fine sandy loam merges with silt loam, it more nearly approaches the latter in its characteristics and in productivity.

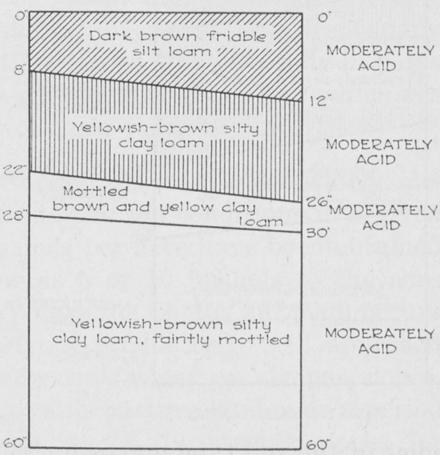
Special precautions to prevent soil blowing and to increase water-holding capacity should be followed when cultivating Tama fine sandy loam. The maintenance of a fine cloddy surface after the soil has been plowed and additions or coarse organic residues such as straw will help to minimize drifting. Additions of organic matter, either in the form of barnyard manure or by the plowing under of green crops, will improve the water-holding capacity of sandy soils. Legumes are desirable green manure crops, but light applications of lime are necessary before good stands can be obtained. Long-time rotations which keep the land in grass or in other close-growing crops for a number of years should be followed wherever possible.

Muscatine Silt Loam, Slope Phase (Ms-x) (264)

The Muscatine silt loam, slope phase, is intermediate in a number of its characteristics between the well-drained and the imperfectly drained groups of dark-colored soils. The topography ranges from very gently sloping to gently rolling, but most areas have sufficient slope to provide adequate surface drainage. Internal drainage—percolation through the soil profile—is slightly restricted in those areas where the soil joins bodies of Grundy silt loam.

Muscatine silt loam, slope phase, occurs in the southern half of the county where it occupies sloping areas adjacent to and below the flat divides. The soil is commonly found on positions with reference to Grundy silt loam comparable to those occupied by Tama soils with respect to Muscatine silt loam. Areas of the Muscatine silt loam, slope phase, are generally narrow, winding slopes; topography ranges from very gently sloping, where the soil borders Grundy silt loam, to gently rolling where is joins Shelby silt loam or other types found on the lower-lying uplands. The soil occurs quite extensively in the southern tier of townships, and the total area makes up 6.5 percent of the county.

The soil profile consists of a friable, dark grayish-brown silt loam, 8 to 12 inches thick, grading into a yellowish-brown horizon that has a silty clay loam texture in the upper portion but becomes heavier with increasing depth. The gradation zone from the dark-colored surface layer to the yellowish-brown silty clay loam is ordinarily 4 or 5 inches in thickness, but occasional dark-colored tongues and streaks extend downward for an additional 4 or 5 inches. Mottlings of gray and orange-brown begin to appear at depths of 24 or 26 inches, become abundant between 30 and 36 inches and then fade below 40 inches. The more highly mottled horizons of the profile are generally the heaviest in texture, usually a silty clay or clay, and there is a change back to a silty clay loam as the mottling fades. The heavier texture and the high degree of mottling in the lower horizons of the profile of Muscatine silt loam, slope phase, serve to differentiate it from Tama silt loam.



MUSCATINE SILT LOAM
SLOPE PHASE

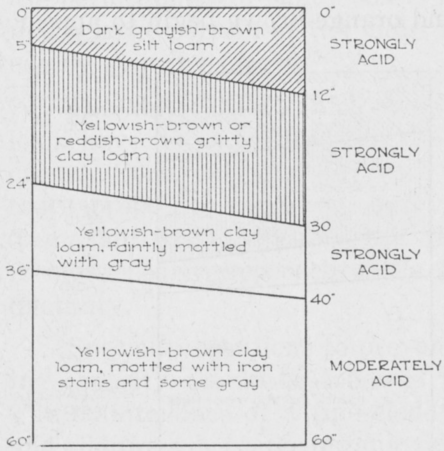
Variations in the profile of Muscatine silt loam, slope phase, are chiefly those in thickness and color of the surface layer with minor ones in the texture of the deeper horizons. When the soil occupies very gentle slopes, the upper horizon is very dark-colored and may range up to 12 or 14 inches in thickness, whereas the horizon is lighter in color, and the depth may be as low as 5 inches on steeper areas. Variations in the texture of the deeper horizons are also associated with changes in topography. The profile of Muscatine silt loam, slope phase, approaches that of Grundy silt loam in a number of characteristics along the mutual boundaries of the two soils. Similarly, the features of the soil profile are more like those of the Shelby or Tama where it joins either of the two latter types.

Problems of soil management on Muscatine silt loam, slope phase, differ from those on other soils of this group in that portions of some areas have slightly restricted drainage. Artificial improvement of drainage may therefore be needed on small acreages of the soil, but the larger acreage is sufficiently drained under natural conditions. Problems of management such as maintenance of the content of organic matter, the prevention of harmful erosion on sloping or rolling areas, and the keeping of favorable soil structure are alike for most of the dark-colored soils of rolling lands.

The large part of Muscatine silt loam, slope phase, is being used for the production of crops with only minor acreages devoted to permanent pasture. The crops grown and the yields obtained on this soil are similar to those on Tama silt loam.

Shelby Silt Loam (Ss) (93)

Shelby silt loam, a Prairie soil overlying glacial till, occurs in the form of narrow, winding bands on stream valley slopes in all parts of Marion County. The strips vary in width from a few hundred feet to as much as half a mile, depending upon the steepness of the slope and the amount of till exposed along the stream valley. Sites occupied by the soil type range from moderately to steeply sloping for the most part, but there are some gently sloping areas. Bodies of Shelby silt loam commonly lie between Tama silt loam or Muscatine silt loam, slope phase, on the higher uplands and the Wabash and associated soils of the bottoms. Occasionally, Shelby areas will adjoin timbered soil types such as Lindley silt loam or Clinton silt loam. Although individual bodies of Shelby soils are seldom large, the aggregate area of all bodies of the soil type makes up 13.7 percent of the county.



SHELBY SILT LOAM

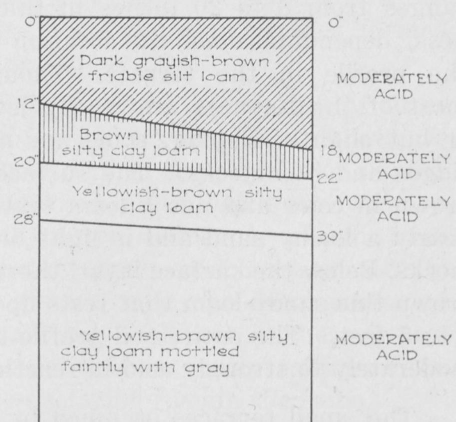
The profile of Shelby silt loam, as it is found on gently sloping positions, consists of a surface layer of dark brown or dark grayish-brown silt loam, 8 or 10 inches deep, and a gradation from the surface horizon through yellowish-brown clay loam into the leached and oxidized glacial till. The glacial till, consisting of a yellowish-brown or brown, gritty clay loam often mottled with gray, is encountered at depths ranging from 24 to 30 inches. Coarse sand, gravel and boulders are present in small numbers throughout the soil profile and are numerous between depths of 30 and 40 inches. Splotches and streaks of lime may sometimes be found below 40 inches, though their occurrence at that depth in gently sloping areas of Shelby soils is uncommon. The entire soil profile is acid as a rule and ranges from slightly to moderately acid in reaction.

Wide variations in profile characteristics may be found in many of the areas of Shelby soils, but they occur most frequently in sharply rolling or hilly regions. In the more gently sloping areas, the different horizons show slight variations in thickness and texture in contrast to the large variations that can be found on the steeper slopes. The range in depth of the surface horizon of the Shelby soils in Marion County extends from 1 or 2 inches to 8 or 10 inches, the deeper horizons being found on the more gentle slopes. On the steepest slopes, particularly where the land has been cultivated, there may be no dark-colored surface layer; the till may be found at or very near the surface. Variability in texture, a frequent characteristic of till materials, is common in areas of Shelby soils, with the range going all the way from sandy loams to clays. Texture variations, for the most part, range from a loam to a clay loam, and these may be found over a distance of a few feet. A patchwork of yellowish-brown clay loam or loam and darker-colored silt loam areas can be observed in many of the moderately sloping to steeply sloping Shelby fields when they are plowed. Occasionally, small pockets of sandy materials will outcrop in bodies of the Shelby soils, but these occupy a small total acreage in Marion County. Similarly, the total area of exposed till of extremely heavy texture is not large. The heavy-textured areas, most of which are gumbotil outcrops, occur along stream valley slopes in a number of places and are usually marked by seepage spots. These gumbotil outcrops, known locally in parts of southern Iowa as "push soils," are dull gray or blue-gray clays which are almost impervious to water, difficult to work and relatively infertile.

Actual yields of crops obtained on Shelby silt loam vary widely, depending upon the particular management and the soil conditions in a given area. Corn yields as high as 40 or 50 bushels per acre have been obtained on well-managed fields, but yields as low as 5 or 10 bushels to the acre have also been obtained in some places. Where the Shelby silt loam occurs on gentle slopes and is carefully farmed, its productivity will approach that of Tama silt loam. Where the Shelby soils occur on steeper slopes, on the other hand, they are most productive as pasture land over a period of years. Anything more than occasional use of the steeper slopes for cultivated crops will expose the soil to serious damage from erosion. Use of the Shelby soils for permanent grassland or long-time rotations with a high proportion of grass is recommended wherever such utilization is possible.

Waukesha Silt Loam (Ws) (75)

Waukesha silt loam, found on level and gently sloping terraces along the larger streams, closely resembles the relatively smooth areas of Tama silt loam, both in profile characteristics and productivity. Individual terraces occupied by the soil are usually small; one or two are as large as 320 acres but most of them are less than 40 acres. Waukesha silt loam is found along the Skunk and Des Moines Rivers, Whitebreast Creek and Cedar Creek. Total acreage of the soil types makes up less than 1 percent of the county area.



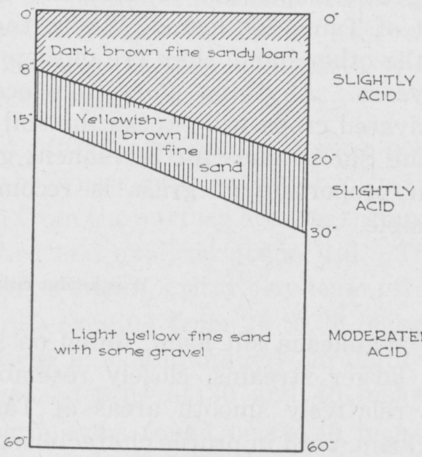
WAUKESHA SILT LOAM

A profile of Waukesha silt loam includes the following horizons: A friable, dark grayish-brown silt loam that extends to depths between 12 and 18 inches; a light yellowish-brown transitional zone, 12 to 14 inches thick, which has a clay loam texture, and the silty alluvium or soil parent material. The alluvium usually consists of a yellowish-brown silty clay loam, but sandy layers may be present and the mass is often faintly mottled with gray and rust-brown. Tongues and streaks of dark-colored soil material from the upper horizon extends downward through the transitional zone, often reaching depths of 22 inches but rarely going down to 30 inches. All of the horizons of the soil are commonly acid.

Waukesha silt loam is fertile, has a high water-holding capacity and is adequately drained. The soil is highly productive and is used for the growing of crops wherever that is possible. Acre-yields of corn obtained on Waukesha silt loam range from 30 to 60 bushels, of oats from 35 to 50 bushels, and of clover-timothy hay from 1 to 2 tons. Legume crops can be grown with only limited success where lime has not been applied.

O'Neill Fine Sandy Loam (Of) (110)

The total area of O'Neill fine sandy loam in Marion County is very small, less than one-half square mile having been mapped. The soil type occurs in the form of small, isolated terraces, usually level or gently sloping, immediately adjacent to the uplands along the valleys of the larger streams. These terraces lie well above danger of overflow from the streams, and many of them have excessive natural drainage because of underlying gravel beds.



O'NEILL FINE SANDY LOAM

The surface layer of O'Neill fine sandy loam is dark brown in color and ranges from 8 to 20 inches in thickness, depending upon the location of the profile in the terrace. Though most of the terraces are nearly level or but slightly sloping, some are marked by small depressions and low ridges and hummocks. The surface horizon of the soil is dark grayish-brown in color and has a loam texture in depressional areas but is more nearly a loamy sand and is light brown in color on the ridges and hummocks. Below the surface layer, there is a transitional horizon of yellowish-brown fine sandy loam that rests upon gravel beds at depths ranging from 3 to 5 feet. The entire soil profile is commonly acid and may range from moderately to strongly acid in reaction.

The small terraces occupied by O'Neill fine sandy loam are all cultivated, probably because of their very favorable topography in a region where much of the land is rolling. Yields of crops obtained are low, however, except in wet seasons, because the soil is porous and has a low water-holding capacity. Crops generally make a rapid growth in the spring, but they suffer from a shortage of moisture later in the season unless rainfall is very evenly distributed throughout the summer. Small grains can be grown more successfully than corn since the grain crops are often ripe before the driest part of the summer season.

Steps to maintain and increase the content of organic matter in the soil are necessary wherever it is to be cultivated successfully. Heavy applications of barnyard manure or the growing and plowing under of green manure crops are desirable methods of keeping up the supply of organic matter. Long-time rotations with a high proportion of grasses will also help to restore organic matter and maintain a favorable soil structure.

LIGHT-COLORED SOILS WITH FREE NATURAL DRAINAGE

The group of light-colored, well-drained soils—all members of the Gray-Brown Podzolic group—include five soil types and one phase in four different series. All of these soils were developed under forest vegetation, and all but one of them occur in the uplands. Three soil types, Clinton silt loam, Clinton fine sandy loam and Weller silt loam occupy gently rolling to rolling uplands; two soils, Lindley silt loam and Clinton silt loam, shallow phase, are found in the sharply rolling areas and on the steep slopes along stream valleys, and Jackson silt loam occurs on terraces. Only three of the soils, Clinton silt loam, Lindley silt loam and Clinton silt loam, shallow phase, cover extensive areas in Marion County. The total acreage of all of the light-colored soils comprises 26.1 percent of the county area.

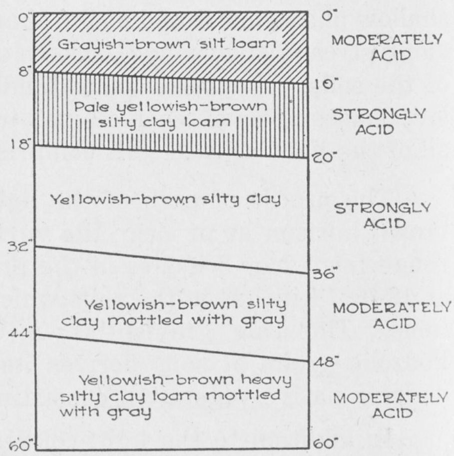
The profile of each of the light-colored soils includes a pale grayish-brown horizon at or near the surface. The thickness of this layer may range from 2 or 3 inches in the profiles found on steep slopes to as much as 12 or 14 inches in the soils which occupy smooth or gently sloping positions. The pale grayish-brown horizon, from which the Gray-Brown Podzolic group of soils derives its name, is developed in profiles formed under a native vegetation consisting of deciduous trees.

In addition to the light-colored surface horizon, the profiles of three soils in the group include an underlying, heavier textured layer known as the B horizon. This B horizon is readily evident in the profiles of Clinton silt loam, Weller silt loam and Jackson silt loam, all of which are found on smooth or gently rolling sites, but it is poorly defined or absent from Lindley silt loam and Clinton silt loam, shallow phase, which occupy steeply sloping or sharply rolling areas. As a general rule, the development of horizons is less complete and those present are shallower in the soil profiles formed on steep slopes than in those found in gently rolling areas, even though parent materials and native vegetation remain the same.

Differences between the light-colored soil types in Marion County are due chiefly to differences in parent materials and topography, with one possible exception. Clinton silt loam and Weller silt loam both have been developed from loess, but the latter soil has either been formed from a heavier-textured deposit or has reached a more advanced stage in profile development. The lower horizons of the Weller silt loam profile are heavier in texture than those of Clinton silt loam. Clinton fine sandy loam has been formed where timber covered light-textured sediments that were blown up from the floodplain of the Des Moines River and deposited over the loess. Clinton silt loam, shallow phase, occurs on steep valley slopes where the covering of loess over shale or limestone is entirely absent or very thin. Lindley silt loam also occupies stream valley slopes, but it has been formed from glacial till, covered by a few inches of loess in many places. Jackson silt loam has developed from silty alluvium in terraces and is comparable in profile characteristics to the Clinton silt loam found on gently sloping positions.

Clinton Silt Loam (Cm) (80)

Clinton silt loam occupies rolling loess uplands along the valleys of the larger streams in Marion County. The soil type commonly adjoins Tama silt loam or Grundy silt loam found in the higher-lying uplands away from the creeks and rivers, and it lies above the Clinton silt loam, shallow phase, or Lindley silt loam of the stream valley slopes. The largest areas of Clinton silt loam border the valley of the Des Moines River in Red Rock Township, but other large bodies are located along the two branches of Cedar Creek, and smaller ones are scattered along Whitebreast, English and Thunder Creeks. The soil type is the most widely occurring of the light-colored ones in Marion County and occupies 11.4 percent of the county area.



CLINTON SILT LOAM

In areas where the soil has been cultivated, the surface horizon of the Clinton profile consists of a grayish-brown or light brown silt loam which has a fine, imperfectly granular structure. The lower boundary of this horizon is not well defined, but there is a gradual change from the grayish-brown silt loam to a pale yellowish-brown silty clay loam between depths of 8 and 10 inches. The second or transitional horizon extends downward to 18 or 20 inches where it grades into yellowish-brown silty clay or clay that is faintly mottled with gray and rust-brown. The gray mottlings gradually become numerous with increasing depth and dominate the soil color in a layer between 36 and 45 inches, but then they fade below 45 inches. The soil material below 44 or 48 inches is a yellowish-brown silty clay loam with scattered mottlings of rust-brown. The entire Clinton profile is acid in reaction, ranging from slightly acid in the surface layers to strongly acid in the deeper, heavier-textured horizons.

Variations in Clinton silt loam as it occurs in the cultivated fields consist largely of differences in depth of the surface layer. On more rolling areas or in fields that have been poorly handled, the surface layer is usually less than 8 inches in thickness and may be entirely absent. On less sloping areas near the tops of the ridges, the depth of the upper horizons may reach 14 inches.

In those locations where Clinton silt loam has not been cultivated, the uppermost horizon of the profile is a dark grayish-brown silt loam, usually 1 or 2 inches thick. Below the surface layer, there is a pale grayish-brown silt loam which digs out in the form of small plate-like aggregates when it is handled carefully. Thickness of the second horizon ranges from as little as 5 inches to as much at 12 inches and averages approximately 8 inches on gently sloping sites. When the soil is cleared and cultivated, the upper horizon of the Clinton profile is mixed with part of the second one and loses its identity, hence the surface layer appears lighter colored and deeper in cultivated fields. The horizons below the surface layers are similar in cultivated and uncultivated areas.

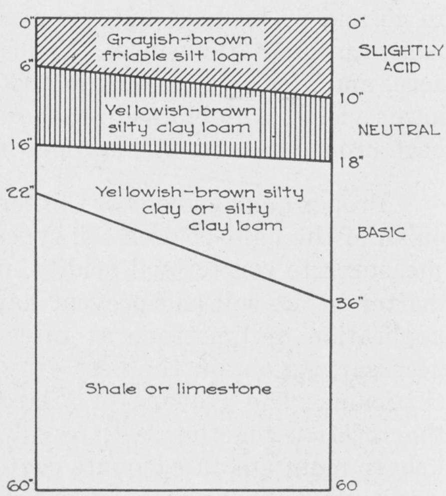
Slightly less than half of the total area of Clinton silt loam in Marion County is being cultivated, the larger part being used as woodland pasture. Crops grown on the cultivated areas include corn, oats and various kinds of hay. Corn occupies a larger acreage of the soil type in any one year than do any of the other crops, although farmers generally recognize that Clinton soils are not well adapted to the production of corn. Acre-yields of corn on gently rolling areas which have been carefully handled range up to 45 and 50 bushels, but the average yield obtained on Clinton silt loam is nearer 25 or 30 bushels. Yields of oats range from 20 to 45 bushels per acre, and yields of clover-timothy hay from 1 to 1½ tons per acre. The lower yields are obtained on the steeper slopes and on fields which have been eroded because of improper handling.

Proper management of Clinton silt loam areas is similar to that needed on all of the light-colored soil types. Management practices should include measures to correct soil acidity, maintain an adequate content of organic matter in the soil and prevent harmful erosion on the rolling lands. The application of limestone at rates ranging from 2 to 4 tons per acre is necessary to obtain the best growth of legumes on most areas of Clinton silt loam. The growing of a large proportion of legumes and grasses in the rotation together with regular applications of barnyard manure will help to maintain an adequate content of organic matter in the soil. It will also be desirable to apply phosphates in many fields where legume crops are to be grown. The maintenance of soil fertility by the use of lime, longer rotations, phosphate fertilizers and applications of manure will also serve to pervent harmful erosion on rolling lands, but the steeper bodies of Clinton silt loam require special care. The seeding-down of waterways, retirement of steep or eroded slopes to permanent vegetation and the use of contour tillage and strip cropping are recommended on the more sloping cultivated lands.

Clinton Silt Loam, Shallow Phase[7] (Cm-x) (262)

Soils developed from shales or interbedded shales and limestones with or without a thin covering of loess have been mapped as Clinton silt loam, shallow phase, in Marion County. Outcrops of shale occur commonly in the valley slopes of the more deeply entrenched streams in the southern part of the county and along the Des Moines and Skunk Rivers. The valley slopes on which outcrops of sedimentary rock are found have the form of long, narrow bands which were originally covered by trees and are still in part forested. Forest vegetation extended over portions of the upland as well as the valley slopes in many places, occupying adjacent areas of Clinton and Weller soils. Bands of Clinton silt loam, shallow phase, lie between upland soils such as the Clinton, Weller and Lindley and the bottomland soils of the Wabash series. Individual areas of the shallow phase are long and winding, seldom including as much as 160 acres, but the total acreage of Clinton silt loam, shallow phase, comprises 6.7 percent of the land in Marion County. Bodies of the soil are most numerous in the southern tier of townships.

Most areas of Clinton silt loam, shallow phase, are found on steep topography where little profile development has been possible. On the steep slopes or in sharply rolling regions, the soil profile consists of a shallow grayish-brown layer, 2 or 3 inches thick, which grades into gray or light gray clay containing numerous fragments of sedimentary rock. Small pieces of shale commonly are found at the very surface of the soil, and the solid rock is seldom deeper than 2 or 3 feet. Loess is usually absent from these steeper slopes, and where it does occur it has been mixed with materials weathered from the underlying rock.



CLINTON SILT LOAM
SHALLOW PHASE

In the scattered, gently rolling areas of Clinton silt loam, shallow phase, the soil profile is deeper with more distinct horizons. The loss of water through rapid runoff and the loss of soil materials as they form through the erosion that accompanies rapid runoff are both smaller in the gently rolling areas than on the steeper lands. The profile of Clinton silt loam, shallow phase, as it occurs in gently rolling areas, consists of a friable, grayish-brown silt loam, 6 to 10 inches thick, below which there is a coarsely granular, yellowish-brown silty clay loam. Dull orange and rust-brown mottlings begin to appear in the silty clay loam horizon between

[7] After the soil survey of Marion County was completed, it was found necessary in other surveys to establish a new series to include soils similar to the Clinton silt loam, shallow phase. In future investigations soils of the general character of this phase will be designated Gosport silt loam.

depths of 14 and 18 inches and become abundant at 22 or 24 inches. At a depth that may range from 22 to 36 inches, depending on the local relief of the land, the silty clay loam merges with a horizon of heavy clay that has been weathered from the underlying rock. The clay horizon overlying the rock is gray in color wherever the bedrock consists of shale, and it is reddish-brown where it overlies interbedded shale and limestone. Small fragments of rock are numerous in the clay horizon immediately above the shale or limestone and may occur throughout the entire profile. The upper part of the profile of Clinton silt loam, shallow phase, in gently rolling areas, however, seems to have been formed from loess with small additions of disintegrated rock materials.

Although most of the Clinton silt loam, shallow phase, was originally forested, it now carries only a scattered growth of trees. The clearing away of forest growth has been more complete in the gently rolling sections than in the bodies of steeper land, and some of the less sloping areas are now being cultivated. By far the larger acreage of the soil is being used as pasture land whether it now supports scattered trees or has been entirely cleared.

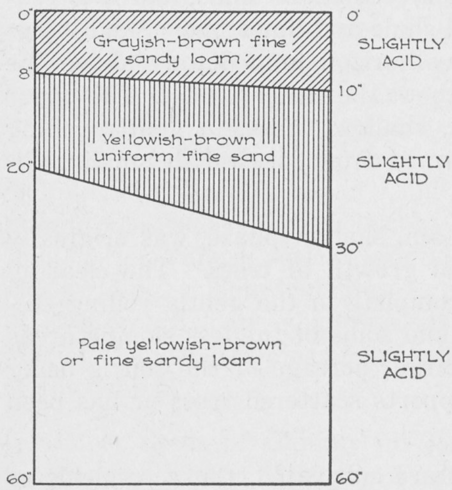
In those gently rolling areas which are cultivated, the acre-yields of corn range from 15 to 35 bushels, depending upon the depth to bedrock and past management of the land. Crops of small grains and hay can be produced more successfully than corn, and they should be grown where the land is to be cultivated. Only the more gently rolling areas of Clinton silt loam, shallow phase, should be cultivated, however, since the steeper bodies are subject to serious erosion when they are cleared and used for crop production. Use of the land for pasture or for the production of trees is recommended for all but the most favorably situated areas of the shallow phase.

Clinton Fine Sandy Loam (Ct) (122)

Clinton fine sandy loam is a minor soil type in Marion County, both from the standpoint of its total extent and production. It occurs only in one area of 320 acres that lies 1½ miles northeast of the town of Harvey on the east side of the Des Moines River. The soil type occupies gently rolling to rolling uplands adjacent to the river floodplain, and it was developed from sandy deposits similar to those from which Tama fine sandy loam was formed but under a different type of vegetation.

The surface layer of Clinton fine sandy loam is grayish-brown in color to a depth of 8 or 10 inches where it merges with a uniform, yellowish-brown fine sand. The depth and texture of the surface horizon and the thickness of the yellowish-brown sand vary with the thickness of the sandy deposit over the heavier-textured loess. On low knolls and ridges the deposit of sand reaches a thickness of 4 feet, and in such areas the surface layer has a loamy fine sand texture and is shallow, whereas the underlying horizon of yellowish-brown sand is thick. Where Clinton fine sandy loam merges with Clinton silt loam, the layer of sand over the loess is only a few inches deep, and the surface horizon of the profile has a very fine sandy loam texture and is quite deep. The underlying horizon of yellowish-brown sand is lacking in such areas.

Clinton fine sandy loam is naturally porous and readily absorbs water from falling rains, but its water-holding capacity is low. Consequently, fair to good yields can be expected only in years with favorable distribution of rainfall over the summer season. In dry years yields will be low or crops may fail entirely.



CLINTON FINE SANDY LOAM

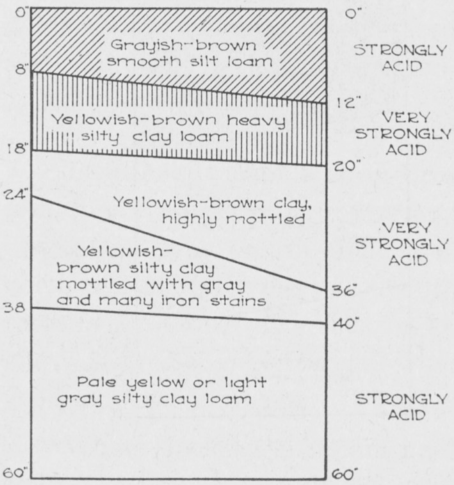
Crops grown on Clinton fine sandy loam include corn, oats, hay, watermelons and cantaloupes. Acre-yields of corn range from 15 to 20 bushels, and those of oats are slightly higher. The production of crops such as watermelons or cantaloupes is perhaps more successful than that of corn or small grains. Limited markets are usually available for the melons, however.

Weller Silt Loam (We) (261)

The occurrence of Weller silt loam is restricted entirely to the southeast and south-central parts of Marion County where it occupies loess uplands that were originally covered by trees. It is found on ridge crests and slopes, sometimes adjoining areas of Clinton silt loam but more commonly bordering Grundy silt loam. Individual bodies of Weller silt loam are generally irregular in outline and relatively small, but a few extend for distances of several miles and occupy as much as 320 acres. The soil type covers only 3,840 acres or 1.1 percent of the land in Marion County.

Where the soil has been cleared and cultivated, the surface horizon of the Weller profile is a smooth, grayish-brown or dark gray silt loam, 8 to 12 inches thick. The second horizon, a transitional layer, consists of a yellowish-brown, heavy silty clay loam extending downward to 18 or 20 inches where it grades into a dense, highly mottled, yellowish-brown silty clay or clay. The clay horizon ranges from 10 to 15 inches in thickness and grades imperceptibly into lighter-textured materials beneath. The soil material below the clay horizon—below 38 or 40 inches—is a friable, pale, grayish-yellow silty clay loam often mottled with yellowish-brown or rust-brown stains. Occasional iron concretions are present in all of the horizons except the surface one, and a broken coating or sprinkling of gray can be found in the heavy clay horizon, especially when it is dry. All of the horizons of the Weller silt loam profile are acid in reaction.

In areas of Weller silt loam which have never been cultivated, the surface horizons of the profile consist of a dark grayish-brown silt loam usually 1 or 2 inches thick, overlying pale grayish-yellow or grayish-brown silt loam with a finely platy structure. This second layer is ordinarily 6 or 8 inches thick, and part of it is mixed with the uppermost horizon when the land is plowed. Below the two upper horizons the profile in uncultivated areas is similar to that found in cultivated fields.



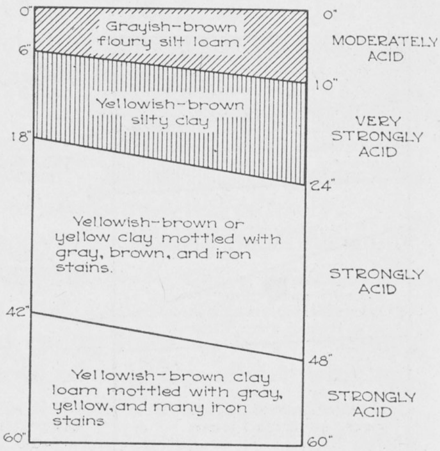
WELLER SILT LOAM

Variations in the profile of Weller silt loam consist largely of differences in depth of the surface layer, although the degree of mottling and the number and distribution of iron concretions also vary slightly from one place to another. Marked variations in the depth of the surface layer can be found in a number of cultivated fields, particularly where the land has been handled improperly and harmful erosion has occurred. The variations in depth of the upper horizons are commonly associated with differences in topography. Thinner surface layers usually occur on sloping areas, whereas deeper surface horizons exist on the more level sites.

Probably less than a third of the area of Weller silt loam is being used for cultivated crops at the present time, and the larger part of it is better suited for use as pasture or timber land. On the smoother areas where crops can be grown with a fair degree of success, yields of small grain and hay will be better than those of corn. Average acre-yields of oats range from 20 to 40 bushels, whereas those of corn are distinctly lower. Good crops of clover or other legumes cannot be grown without previous applications of lime on Weller silt loam. A more general use of lime, applications of manure where possible and longer rotations with more legumes and grasses are recommended for the cultivated areas of Weller soils. Steeper areas should not be cultivated but should be kept in permanent vegetation and used for pasture or the production of trees.

Lindley Silt Loam (Ls) (32)

Lindley silt loam has developed from outcrops of Kansan till, often covered by a thin veneer of loess, on steep valley slopes and in sharply rolling areas. The wooded, rather hilly and broken areas characteristic of the soil type can be found in all portions of the county, but they are most common along the larger creeks and streams. Lindley soils are usually bordered by Clinton or Tama soils on the higher-lying uplands and by soils of the Wabash series in the stream bottoms. Areas of Lindley silt loam were originally forested, but many of them now have been partially or entirely cleared of trees. Cleared areas are used for pasture where the land is steep or for cultivation in the less widely distributed ones where the topography is rolling. Whether the topography is rolling or steep depends chiefly upon the width of the band of Lindley soils along the valley slope. Most individual areas are narrow; only a few are wide enough so that some rolling bodies of land are included. Although individual bodies of Lindley silt loam are small, their total acreage comprises 6.6 percent of the land in Marion County.



LINDLEY SILT LOAM

There has been very little profile development in the Lindley soils which occur on the steeper valley slopes. In these steeper areas the surface layer is a grayish-brown or light grayish-brown loam clay loam or silt loam which grades into till materials at depths ranging from 2 to 8 inches. The till is most commonly a yellowish-brown or brown clay loam although it may range in color from blue-gray to dull yellow and in texture from sand to clay. The shallow Lindley profile with till near the surface occurs more extensively than the deeper one which is limited to gently rolling areas.

In the gently rolling areas of Lindley silt loam, a thin covering of loess makes up part of the soil material and largely determines the texture of the surface horizon. The profile found on these less sloping locations consists of grayish-brown or light grayish-brown silt loam, 6 or 8 inches thick, overlying yellowish-brown, gritty clay loam that becomes lighter in color with increasing depth. Glacial till is usually encountered at 18 to 24 inches, and it differs slightly from the overlying transitional horizon. Mottlings of rust-brown or gray and occasional pockets of sand characteristically occur in the till, and pebbles, rock fragments and boulders are common though not especially numerous. All of the horizons of the Lindley profile as found on gently rolling positions are acid in reaction.

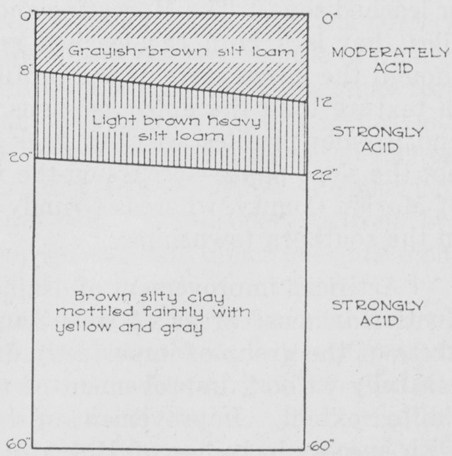
Most bodies of Lindley silt loam are being used as pasture or timber land, with a limited acreage in cultivated fields. Since the larger acreage of the soil type does occur in sharply rolling or hilly areas, it is better adapted for pasture or timber production than for the growth of crops. Attempts have been made to cultivate some of the steeper slopes, but such fields are largely abandoned at the present time. Steep areas of Lindley silt loam are in serious danger of erosion whenever they are cultivated, and crop production should be limited to gently rolling areas.

Gently rolling areas which can be successfully cultivated are better adapted to the growing of small grains and hay crops than corn. Acre-yields of corn range from 15 to 25 bushels on better fields and may be considerably lower on poor tracts. Satisfactory production of crops on Lindley silt loam requires that steps be taken to increase the content of organic matter and nitrogen in the soil, to correct acidity by lime applications and to prevent harmful erosion on sloping lands.

Jackson Silt Loam (J1) (81)

Jackson silt loam, a Gray-Brown Podzolic soil found on terraces, occupies only 1 square mile in Marion County. One of the two largest bodies of the soil type occurs along Whitebreast Creek, approximately 2 miles northwest of Knoxville, and the other lies along English Creek north of the town of Durham. The Jackson soils are found on terraces which lie well above danger of overflow and which are usually sloping enough to provide good external drainage.

Where Jackson silt loam has been cultivated, the surface layer consists of a light brown or grayish-brown silt loam with an average thickness of approximately 10 inches. Below the surface layer there is a light brown, heavy silt loam, sometimes streaked with gray, that extends downward to 20 or 22 inches. This light brown transitional layer overlies a brown silty clay faintly mottled with yellow—the B horizon—which ranges from 10 to 15 inches in thickness. The brown silty clay horizon has a poorly defined lower boundary and grades into pale grayish-yellow silty clay loam somewhere between 35 and 45 inches. All of the horizons in the Jackson profile are acid, ranging from slightly to moderately acid in reaction. Jackon silt loam closely resembles Clinton silt loam which occurs on the more gently sloping uplands, differing only in that its upper horizon contains more fine sand than that of the Clinton profile.



JACKSON SILT LOAM

Because of its smooth topography, Jackson silt loam is free from danger of harmful erosion under cultivation, and nearly all areas of the soil type are cultivated. The soil is generally somewhat acid and lower than optimum in its content of organic matter, however, so that crop yields are improved by applications of lime or manure. Acre-yields of corn obtained on Jackson soils are lower than those from the dark-colored upland soils, but the yields of oats and hay are above the general averages for the county.

IMPERFECTLY DRAINED SOILS OF THE UPLANDS AND TERRACES

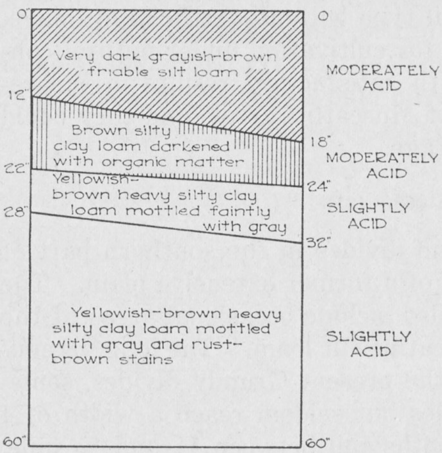
Imperfectly drained soils of the uplands and terraces include six soil types in five different series which occupy 13.5 percent of the land in Marion County. All of the soils have dark-colored surface horizons and tend to be Prairie-like in nature, but they differ from the well-drained Prairie soils because they were developed on sites where natural drainage was limited by the flat topography. Three of the soil types are found on the flat divides in the uplands, and the other three are found on terraces. Grundy silt loam, Muscatine silt loam and Putnam silt loam were all developed from loess in flat upland areas, whereas Bremer silt loam, Bremer silty clay loam and Chariton silt loam are found on smooth terraces that are elevated slightly above the floodplains of the streams.

All of the soils in this group are alike in that they have fairly dark-colored surface layers overlying mottled, heavier-textured materials in the lower part of the soil profile. All of them have been developed from sediments composed largely of silts and clays, deposited by wind action in the uplands and by water in the terraces. The profiles of the various imperfectly drained soils differ, however, in the thickness and color of the surface horizon and in the degree of development of the heavier-textured subsoil. Rather light-colored and shallow surface horizons are associated with very dense and mottled subsoils in the profiles of Putnam silt loam and Chariton silt loam. Leached horizons which are light gray in color occur between the darker-colored surface layer and the heavy, mottled horizons in these soil profiles. The Grundy profile has a dark, deep surface horizon and a fairly well-developed claypan layer, but it lacks the intermediate gray or leached zone. The Muscatine and Bremer soils are characterized by profiles that lack both the leached gray layer and the heavy claypans, although the lower parts of the profile tend to be more mottled and heavier in texture than the upper portions. The surface layers of the Muscatine and Bremer profiles are very dark and very deep. Muscatine silt loam—not the slope phase—occurs on the flat upland divides in the northern part of Marion County, whereas Grundy silt loam occupies the comparable sites in the southern townships.

Artificial improvement of drainage is necessary for maximum crop production in most areas of soils found on flat uplands or terraces. Some areas of the group of imperfectly drained soils can be cultivated quite successfully without improvement of natural drainage, but such areas are of limited extent. Improvement of drainage by means of tile has been used with success in bodies of Muscatine silt loam, whereas the use of ditches is more common on the Bremer terraces. Soil types such as Putnam silt loam and Chariton silt loam are very difficult to drain because of their impervious claypan horizons; ditches have been dug in a few areas, but the soils are generally used in their natural, imperfectly drained condition. Grundy silt loam is intermediate in its characteristics between the Muscatine and Bremer soils on the one hand and the Putnam and Chariton soils on the other. The Grundy profile does include a heavier-textured claypan or subsoil horizon which restricts downward percolation and materially reduces the distance over which tile will draw.

Muscatine Silt Loam (Ms) (30)

The higher-lying, smooth upland divides in the northern half of Marion County are occupied chiefly by Muscatine silt loam, though there are occasional isolated bodies of Grundy silt loam present. Long, irregularly winding bodies of Muscatine silt loam, usually surrounded by larger areas of Tama soils, can be found in all but the southernmost tier of townships. Occasional small areas of the soil type also occur as islands in larger bodies of Grundy silt loam in the southern townships. The largest single area of Muscatine silt loam is found in the western part of Marion county; it includes the site of Pleasantville and extends for several miles in a northwest-southeast direction. The total acreage of all bodies of Muscatine silt loam comprises 4.7 percent of the county area.



MUSCATINE SILT LOAM

The Muscatine profile consists of three horizons: A finely granular, very dark grayish-brown silt loam; a transitional horizon of yellowish-brown, heavy silty clay loam; and the grayish-yellow, mottled loess or parent material. The boundaries between the different horizons are poorly defined, but the change from the surface layer to the transitional horizon generally occurs between depths of 12 and 18 inches. Occasional gray and rust-brown mottlings and a few small iron concretions are present in the transitional layer below 22 and 24 inches, and they become quite common in the loess below depths of 32 or 40 inches. The soil material below 40 inches consists of a grayish-yellow or yellowish-brown silty clay loam that is faintly mottled. The deeper horizons are either neutral or slightly acid in reaction, whereas the upper ones are moderately acid.

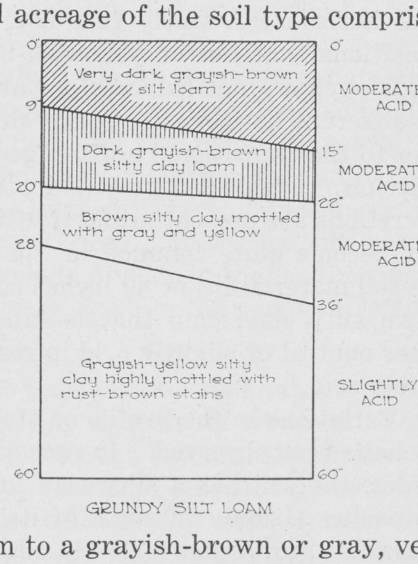
Variations in the profile of Muscatine silt loam are not common, but a few have been observed. In occasional depressed pockets in the Muscatine divides, the soil has a silty clay loam texture in the surface horizon and approaches Grundy in some of its profile characteristics. Similarly, the Muscatine profile more closely resembles that of the Grundy along their common boundaries, since there is a very gradual transition from the one soil type to the other. Where it lies adjacent to bodies of Grundy silt loam, the Muscatine profile is more distinctly mottled and heavier in texture in the deeper horizons than was indicated in the preceding paragraph.

All areas of Muscatine silt loam are being used for the production of crops or as rotation pasture. Crops grown are chiefly corn, oats and clover-timothy hay with smaller acreages of additional minor crops. Acre-yields of corn range from 45 to 55 bushels on most fields, but they often reach 65 or 75 bushels on well-handled farms. Yields of oats are somewhat lower than those of corn and range from 30 to 60 bushels per acre, depending upon the seasonal conditions and past management of the land. Clover-timothy hay yields from 1½ to 2½ tons per acre, whereas alfalfa will yield from 3 to 4 tons per acre in fields that are well drained and have been limed.

Artificial improvement of drainage is generally necessary for highest crop production on Muscatine silt loam. Fairly satisfactory yields of crops can be obtained on many areas of the soil type without artificial drainage, however, and a few are entirely suitable for cultivation under natural conditions. Tile drains have been used with satisfactory results in the removal of surplus water from a number of Muscatine areas, and they could be used more extensively to good advantage.

Grundy Silt Loam (Gs) (64)

Grundy silt loam occupies flat upland divides in the southern part of Marion County, apparently the remnants of a former extensive plain. The upland flats in the northern townships also include occasional areas of the soil type, but they consist largely of Muscatine silt loam. The long, irregular and winding areas which constitute the present Grundy divides, sometimes extend for distances of 5 or 6 miles but seldom reach a width of 1 mile. The most commonly occurring widths fall between ¼ and ½ mile. Individual areas of Grundy silt loam are usually surrounded by a band of Muscatine silt loam, slope phase. Total acreage of the soil type comprises 6.5 percent of the land in Marion County.



GRUNDY SILT LOAM

The profile of Grundy silt loam consists of four principal horizons which grade into one another and are not separated by distinct boundaries. The surface layer, 10 or 12 inches thick, is a friable, very dark grayish-brown (almost black) silt loam with an imperfectly developed, finely granular structure. The second horizon, which has a well-defined granular structure, consists of dark grayish-brown silty clay loam and extends to depths of 20 or 22 inches. There is a rather abrupt change from this layer of silty clay loam to a grayish-brown or gray, very heavy clay, which is highly mottled with yellowish-brown and orange-brown stains. When it is dry, the clay digs out in large vertical pieces, ranging from 6 to 10 inches in length and from 3 to 4 inches in diameter, which are very dense and intractable. When wet, however, the clay is extremely sticky and plastic. Soft, small iron concretions are present in all parts of the profile except the surface horizon, but they are especially numerous in the heavy-textured clay layer (the B horizon). The claypan layer or B horizon usually merges with the grayish-yellow silty clay loam of the parent loess between 28 and 36 inches. The entire profile of Grundy silt loam is acid in reaction, and the lime requirement of the surface horizon commonly equals 3 tons of limestone per acre.

Variations in the profile of Grundy silt loam are slight and are of very limited extent. Depths of the surface horizon may range from 9 to 14 inches, and a thin, gray, platy layer may sometimes be observed below the uppermost horizon in the profile. The light-colored horizon is commonly found in depressional spots within the generally flat divides. If extensive areas of soil with a gray, leached horizon as part of the profile had occurred in Marion County, they would have been mapped as Edina silt loam.

Drainage is restricted in areas of Grundy silt loam, partly because the relief is so slight and partly because the lower horizons of the profile are slowly permeable to water. Drainage is particularly slow in the central portions of some of the larger flats. Most areas other than the central parts of the divides are used for crop production without improvement of natural drainage, but plant growth is generally more satisfactory where it has been possible to remove surplus water, either by the use of tile or through open ditches.

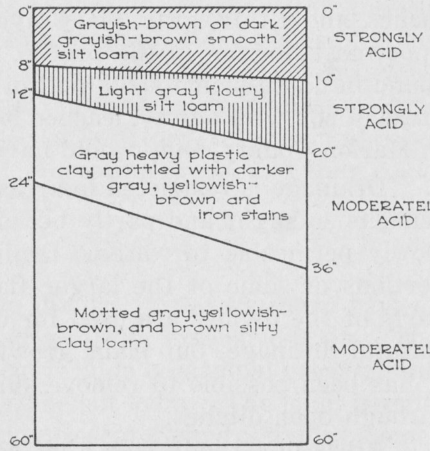
Areas of Grundy soils that have been drained and properly managed are among the most productive ones in Marion County. The average acre-yield of corn on Grundy silt loam is approximately 45 bushels, but yields as high as 75 bushels per acre are obtained on well-managed fields where legumes are grown regularly in the rotation. Corn yields commonly range from 35 to 55 bushels per acre and are distinctly higher than yields of oats. Oat crops grown on areas of Grundy silt loam occasionally lodge because of the high contents of organic matter and nitrogen in the soil, and this reduces the average production appreciably. Yields of oats in favorable seasons range from 35 to 50 bushels per acre. Hay crops grown on Grundy silt loam are chiefly clover-timothy mixtures and timothy alone. Yields of hay range from 1 to 2 tons per acre. Barley and wheat are grown occasionally on the Grundy soils, but the total acreage in any one year is small.

Careful management of Grundy silt loam should include the application of lime to correct acidity, steps to improve natural drainage conditions wherever that is feasible, and the maintenance of fertility by additions of organic matter and fertilizers as needed. The lime requirement of the surface layer of the Grundy soil usually ranges from 2 to 4 tons of limestone per acre. Applications of limestone are necessary in order to obtain catches of alfalfa or sweet clover and are desirable to promote better growth of red clover. The use of tile drain or ditches to remove surplus water will permit earlier working of many of the fields in the spring and can be used in a number of places. Additions of organic matter, either in the form of barnyard or green manure, and the application of fertilizers are desirable so as to maintain the fertility of Grundy silt loam at high levels.

Putnam Silt Loam (P) (66)

Putnam silt loam occupies 512 acres on the flat upland divides in the extreme southeastern part of Marion County. The soil type sometimes occurs within larger bodies of Grundy silt loam, but more commonly it lies between areas of Grundy and Clinton or Weller soils. Most of the Putnam silt loam exists in the form of relatively narrow strips.

The surface layer of the Putnam profile is a loose, dark grayish-brown to grayish-brown silt loam, 8 to 10 inches deep. Below the surface layer there is a light gray silt loam horizon, 3 to 10 inches thick, which has a finely platy structure in place but crushes readily to a soft, floury mass when it is removed. A few small iron concretions are present in this light gray horizon. The lower boundary of this gray, leached layer is quite distinct and separates it from a very dense, dull gray clay, highly mottled with yellowish-brown and rust brown stains. The heavy clay horizon is extremely hard and intractable when dry, sticky and plastic when wet, and contains numerous iron concretions or small pellets. The heavy, dull gray clay becomes somewhat lighter both in color and in texture with increasing depth and merges with the grayish-yellow silty clay loam of the loess parent material somewhere between 24 and 36 inches. The loess is much more friable than the claypan layer but distinctly less friable than the surface horizons of the profile. All of the horizons of Putman silt loam are distinctly acid.



PUTNAM SILT LOAM

The natural drainage of Putnam silt loam is poorer than that of Grundy silt loam, largely because the claypan layer in the former soil is less permeable than that in the latter profile. The claypan horizon of the Putnam profile is distinctly more compact and dense than that of the Grundy profile. Topography on which the two soils are found differs very little; both occupy flat upland divides. Because of the heavy and compact subsoil and the lack of relief, improvement of the drainage of Putnam silt loam is very difficult.

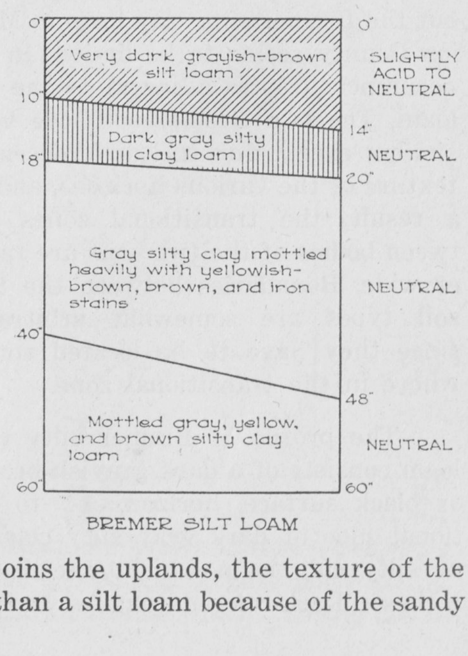
The crops produced on Putnam silt loam include all of those that are common to the region, but oats and hay are grown with more success than corn. The heavy claypan layer tends to limit the root zone of plants, and thus more seriously hampers the growth of corn than that of shallower-rooted plants such as oats. Acre-yields of oats or barley range from 15 to 35 bushels per acre in most years, whereas those of corn are distinctly lower. Legume crops, particularly alfalfa and sweet clover, are not often grown on Putnam areas because of the inadequate drainage and the high degree of acidity of the soil. Timothy has been grown with fair success on much of the soil type, with yields of hay ranging up to 1½ tons per acre.

Steps to improve the productivity of Putnam silt loam should include the application of lime and organic matter and the growing of crops such as sweet clover to increase the permeability of the claypan layer. Additions of lime at rates ranging from 3 to 4 tons per acre are necessary before sweet clover can be grown successfully. The growing and plowing under of sweet clover will tend to increase the content of organic matter in the soil, and further additions of organic matter such as barnyard manure are also desirable. Improvement of natural drainage by means of tile is generally not feasible in areas of Putnam silt loam, but ditches can be used to good advantage in some places. After the productivity of Putnam silt loam has been improved by the use of lime, sweet clover, manure and drainage, yields of crops will still be lower than those obtained from better soil types such as Muscatine silt loam.

Bremer Silt Loam (B) (88)

Bremer silt loam occupies low terraces that are found principally along the Des Moines River, Skunk River, Whitebreast Creek and Cedar Creek. These terraces usually lie from 2 to 5 feet above the level of the first bottoms and have a slight slope toward the stream channel. Bodies of Bremer silt loam are usually small, and only the exceptionally large areas include as much as 500 acres. Total acreage of the soil type comprises 1.5 percent of the land in Marion County. Bremer silt loam often occupies the entire area of the terrace on which it occurs, but it is sometimes associated with Bremer silty clay loam and the Waukesha or Chariton soils.

The surface layer of the Bremer profile is a very dark grayish-brown silt loam which appears black when wet. This surface layer merges with a second, transitional horizon of dark gray silty clay loam at depths of 10 or 14 inches. There are a few mottlings of yellowish-brown in the upper part of the transitional horizon, and there are numerous mottlings at depths of 18 or 20 inches where the silty clay loam gives way to light gray silty clay. Below 40 or 48 inches, the soil material is most often a grayish-yellow silty clay loam mottled with dull orange and rust-brown. The reaction in the different horizons of the soil profile ranges from slightly acid to neutral.



BREMER SILT LOAM

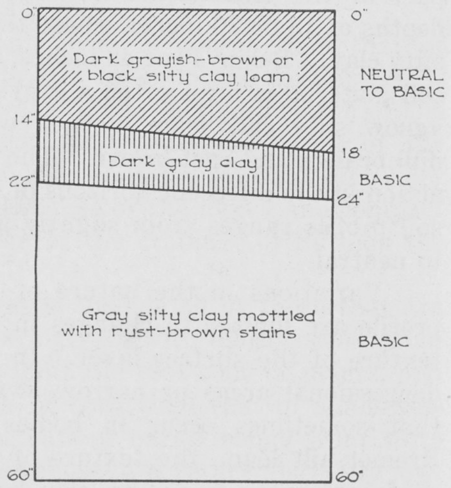
Variations in the nature of the profile are limited to changes in the texture of the surface layer. In the depressional areas or narrow swales that sometimes occur in bodies of Bremer silt loam, the texture of the surface horizon is a silty clay loam. If such areas had been somewhat larger, they would have been mapped as Bremer silt clay loam. In a number of places where Bremer silt loam joins the uplands, the texture of the surface horizon is more nearly a loam than a silt loam because of the sandy materials washed down from higher-lying outcrops of till or similar deposit. Areas of Bremer soils in which the upper horizon has a loam texture are somewhat more productive than the bulk of the soil type.

Drainage over the surface of Bremer soil is slow because of the gentle slope, and percolation downward through the profile is limited to some extent by the heavy texture of the deeper horizons. Some improvement of drainage is needed on most areas of Bremer silt loam to insure maximum crop production, and ditches or tile have been used for this purpose in a number of places. Further use of ditches or tile drains appears to be feasible.

Almost all bodies of Bremer silt loam are cultivated, and some areas have been used continuously for the production of corn. In favorable seasons corn yields range from 40 to 50 bushels per acre, whereas those of oats range from 30 to 45 bushels per acre. A small amount of wheat is usually grown on the soil type in addition to corn, oats and hay, but the acreage is very limited. Hay crops, chiefly timothy or clover-timothy mixtures, produce from 1 to 2 tons per acre when grown on Bremer silt loam.

Bremer Silty Clay Loam (Bs) (43)

Bremer silty clay loam, a minor soil type occupying less than 2 square miles in Marion County, is found on terraces along the Des Moines and Skunk Rivers. The silty clay loam seems to occur is the lower-lying portions of terraces which are also partly occupied by Bremer silt loam. The latter soil type occupies entire terraces or may be associated with soils such as the Waukesha or Chariton, but the Bremer silty clay loam in Marion County seems to be limited in its occurence to sites adjacent to the silt loam. The two Bremer soils are very similar except for the differences in texture of the various horizons, and as a result, the transitional zones between bodies of the two soils are rather wide. Boundaries between the two soil types are somewhat arbitrary, since they have to be located somewhere in the transitional zone.



BREMER SILTY CLAY LOAM

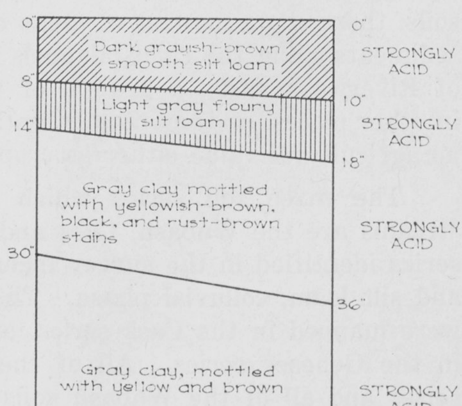
The profile of Bremer silty clay loam consists of a dark grayish-brown or black surface horizon, 14 to 18 inches thick, a streaked transitional zone of dark gray silty clay, and a mottled, light gray silty clay or silty clay loam which extends downward from depths of 22 or 24 inches. Dark-colored tongues and streaks, varying from 4 to 8 inches in length, reach down from the surface layer into the transitional horizon and sometimes penetrate the light gray silty clay beneath. Rust-brown stains and small iron concretions are common in the soil profile below depths of 30 or 34 inches. The soil reaction ranges from slightly acid to neutral or basic, becoming less acid with increasing depth.

The texture and color of the surface layer of Bremer silty clay loam vary somewhat from place to place. In the lower-lying areas of the soil type, the uppermost horizon contains a larger proportion of clay than usual, and the texture is a silty clay. Where the silty clay loam adjoins Bremer silt loam, however, the surface layer is more silty in nature. Darker colors of the surface horizons are usually associated with heavier textures.

Natural drainage is poor over all of Bremer silty clay loam, and it is especially poor where the soil type is found in depressional areas or swales. A number of swales or depressed areas have been drained, but some have not, and these undrained areas now support a vegetation composed of sedges, rushes and other water-loving plants. They are utilized to some extent as pasture land, but they cannot be used for the production of crops. The better-drained areas of Bremer silty clay loam are used for the growing of crops of corn or hay with only limited acreages of small grains. Oats lodge readily on the silty clay loam so that average yields are low, and the yields of other crops are also considerably lower than the ones obtained on Bremer silt loam.

Chariton Silt Loam (Ch) (105)

Chariton silt loam occurs on terraces which lie well above danger of overflow along the valleys of Cedar, Whitebreast and English Creeks. Individual areas of the soil type range from 10 to 320 acres, but the smaller ones are much commoner. The aggregate area of Chariton silt loam in Marion County amounts to slightly more than 2 square miles.



CHARITON SILT LOAM

The upper horizon of the Chariton profile is a smooth, dark grayish-brown silt loam which ranges from 8 to 10 inches in thickness and is underlaid by a light gray, platy layer. The boundary between the two horizons is not sharply defined but consists of a transitional layer several inches thick. The light gray, platy horizon may vary from 4 to 8 inches in thickness and is marked by a number of small, black concretions and many thread-like brown stains. Below 14 or 18 inches the soil material consists of a heavy, dull gray clay, highly mottled with yellowish-brown and rust-brown stains, which extends downward to depths of 30 or 36 inches. This heavy-textured or claypan layer is dense and compact, but it seems to be slightly more friable and less impervious than the corresponding horizon in the Putnam profile. The claypan grades into the lighter gray silty clay loam or silt loam of the soil parent material at depths of 38 to 42 inches. All of the horizons in Chariton silt loam are distinctly acid, and the reaction ranges from strongly to moderately acid.

Variations in the soil mapped as Chariton silt loam are few and scattered. In a number of small areas, the surface layer of the soil is light grayish-brown, and the claypan horizon is more compact and sticky than usual. These areas would have been indicated as Calhoun silt loam had they been extensive enough to be shown separately.

Most Chariton silt loam is now being cultivated, and the common field crops of the county are produced. Yields of corn, oats and mixed hay obtained on Chariton soils are distinctly lower than the ones obtained on Bremer silt loam, partly because of the lower fertility and partly because of the more restricted drainage. Improvement of the fertility of the soil by means of applications of manure, lime and fertilizers and the improvement of drainage wherever possible will increase the productivity of Chariton silt loam. Artificial improvement of drainage is expensive where the areas of the soil type are large, but it can be accomplished more readily where they are small.

SOILS OF THE BOTTOMLANDS

Soils found in the stream bottoms of Marion County include seven soil types and one phase in three different series. In addition to these soils, there are a number of areas of recently deposited sandy or gravelly sediments along the river channels which were called Riverwash. Deposits of Riverwash carry a growth of willows in some places, annual weeds in other places, or they may be entirely barren of vegetation. They have no agricultural value either as crop or pasture land.

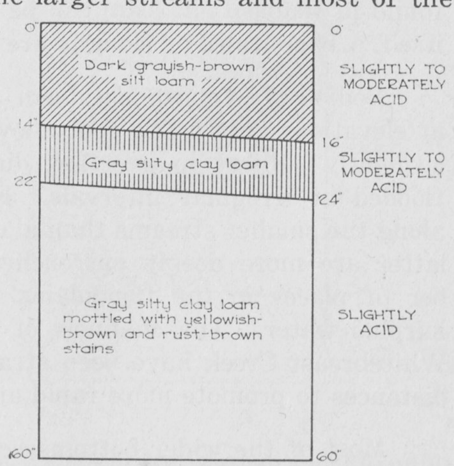
The three soil series which occur in the bottomlands along the streams are the Wabash, Cass and Genesee. Members of the Wabash series identified in the survey include the loam, silt loam, silty clay loam and silt loam, colluvial phase. The fine sandy loam and silty clay loam were mapped in the Cass series, and the silt loam and fine sandy loam in the Genesee series. All of the soil types in the Cass and Genesee series and all of the Wabash soils except the silt loam, colluvial phase, occur in the floodplains of the rivers and the larger creeks. Wabash silt loam, colluvial phase, is found along upland drainageways, but only 192 acres of the soil were mapped in Marion County. Wabash silt loam—not the colluvial phase—occurs along the smaller streams that lead back to the uplands as well as in the floodplains of the rivers and large creeks. This soil type is the most extensive of those occurring in the stream bottoms; individual areas sometimes cover as much as 3 or 4 square miles. Other soil types which occupy large acreages in the county are Wabash silty clay loam and Cass fine sandy loam. The remaining soils of the stream bottoms occur in the form of small, scattered areas. The total acreage of all of the soils found in the bottomlands comprises 17.7 percent of Marion County.

Generally speaking, the soils found in stream bottoms have poorly developed profiles, are subject to overflow when the streams leave their channels and are imperfectly drained. One exception to this general rule occurs in Marion County. The profile of Wabash silt loam, colluvial phase, does lack well-defined horizons, but the soil is less subject to overflow or restricted drainage. All of the other soils in the group are both subject to overflow and imperfectly drained in addition to lacking well-developed profiles. None of the soils in the bottomlands has reached a stage in profile development comparable to that of types found on the smoother uplands, as for example Tama silt loam or Clinton silt loam.

The soils of the Wabash series have dark-colored surface horizons overlying heavier-textured, somewhat mottled subsoils. The Cass soils differ from the Wabash in that they overlie sandy or gravelly alluvial materials instead of silts and silty clays. The Genesee soils are characterized by light colors throughout the entire vertical section; they apparently consist of sediments derived from the surface horizons of the light-colored, timbered soils of the uplands. All of the soils in the stream bottoms have been formed or are in process of formation from alluvial deposits.

Wabash Silt Loam (Wl) (26)

Wabash silt loam is the most extensive of the soils found in the bottom lands and occurs along all of the larger streams and most of the smaller ones in Marion County. It is not ordinarily found along intermittent streams or drainageways extending back into the uplands, but it may occur along any of the streams which have developed floodplains. In the bottoms of the larger streams, Wabash silt loam is commonly associated with Wabash silty clay loam and Cass fine sandy loam, but it may border areas of Wabash loam or Riverwash. Along the smaller streams Wabash silt loam commonly occupies the entire floodplain except for occasional areas of other soil types that are too small to be indicated.



WABASH SILT LOAM

Individual bodies of the soil type may cover as much as 3 or 4 square miles, or they may exist as narrow bands covering only a few acres. The aggregate area of Wabash silt loam is quite large, making up 10.8 percent of the land in Marion County.

There are no well-defined horizons present in the profile of Wabash silt loam. The surface layer of very dark grayish-brown or black silt loam extends down to depths of 14 or 16 inches where it grades into a gray silty clay loam. Very little further change occurs in the vertical section through the soil, even as far down as 40 or 50 inches. There is a gradual change toward lighter colors with increasing depth, and mottlings become more pronounced below 22 or 24 inches. Interbedded layers of sand and silt may sometimes be found below the soil or even in the upper parts of the profile.

Variations in the profile of Wabash silt loam are common, as they are in most young soils formed or forming from alluvial materials. Changes in the texture of the surface layers can be found in most areas of the soil type, and some variability in the deeper horizons also can be noted. Where Wabash silt loam borders the channel of one of the smaller streams or adjoins bodies of Riverwash, all of the layers in the profile are lighter in texture than described. Narrow strips of sandy loams or loams near stream channels also have been included with the larger areas of Wabash silt loam because of their small size. Occasionally there are some light-colored spots of soil where sediments from timbered soils have been washed down over Wabash silt loam. Such light-colored areas are mapped as Genesee soils wherever they are large enough to be indicated. In a few places there are remnants of old channels in the form of swales or sloughs, and these are now occupied by a soil resembling Wabash silty clay loam. Many of these swales are so narrow that they cannot be indicated on a map of a scale of 1 inch per mile and have therefore been included with Wabash silt loam. Except for the heavy-textured soils found in the swales or sloughs, all of the variations found in Wabash silt loam can be handled in the same manner as the soil itself. The swales or sloughs are generally not suitable for cultivation.

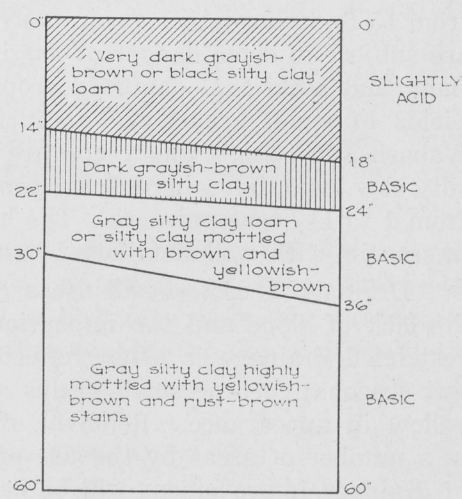
Bodies of Wabash silt loam are flat or very gently sloping and lie at elevations only a few feet above the stream channel. The soil is consequently subject to overflow during all periods of high water and is flooded at irregular intervals. Flooding or overflow is more frequent along the smaller streams than along the larger ones, probably because the latter are more deeply entrenched. Ditches have been dug in a number of places in the floodplains of the larger streams to help remove surplus water. The channels of streams such as the Skunk River and Whitebreast Creek have been straightened and deepened for considerable distances to promote more rapid and thorough drainage.

Most of the wider bottoms occupied by Wabash silt loam are now in cultivation, whereas the smaller ones are used chiefly as permanent pasture. In the cultivated areas in the larger floodplains, corn is the principal crop grown with acre-yields ranging from 40 to 60 bushels. Relatively large acreages of wheat and oats are also produced on Wabash silt loam, though proportionately less wheat is grown on the soil type than on Wabash silty clay loam. Wheat yields range from 15 to 30 bushels per acre and those of oats from 40 to 45 bushels per acre in favorable years. Clover-timothy hay is grown on a number of farms in the bottomlands, and yields from areas of Wabash silt loam range from 1½ to 2 tons per acre.

The narrower floodplains occupied by Wabash silt loam are often bordered by steep areas of Shelby silt loam, Lindley silt loam or Clinton silt loam, shallow phase, in addition to having irregular surfaces. These smaller bottoms are difficultly accessible because of the adjoining steep topography and are more often flooded than are the big bottoms. Furthermore, many of the smaller floodplains carry a scattered stand of brush and trees which would have to be removed before they could be cultivated. Much Wabash silt loam found in the bottoms along the smaller streams is now used for pasture, and it supports good stands of bluegrass, especially where trees and brush are absent. The narrow floodplains are more valuable when used as pasture than when cultivated, since they tend to remain green much later in the summer than do the uplands and furnish grazing at a time when other permanent pastures are short.

Wabash Silty Clay Loam (Wc) (48)

Wabash silty clay loam occurs chiefly along the Des Moines and Skunk Rivers, but a number of areas can also be found in the floodplain of Whitebreast Creek. One small area of the soil type is located in the valley of Cedar Creek in the northeastern part of Liberty Township and another along English Creek in Knoxville Township. Wabash silty clay loam occupies flat or depressed basin-like areas in the stream bottoms, and it is associated with Wabash silt loam on higher-lying sites or adjoins Cass fine sandy loam developed from coarse-textured sediments. Individual bodies of Wabash silty clay loam are usually large, ranging up to 4 or 5 square miles in the bottoms of the Des Moines and Skunk Rivers. Some small areas do occur, but they are much less common than the big ones. Total acreage of Wabash silty clay loam ranks second among that of the soil types in the stream bottoms and comprises 4.3 percent of the land in Marion County.



WABASH SILTY CLAY LOAM

Wabash silty clay loam is subject to more restricted drainage than most of the soils of the floodplains, and this is indicated by the nature of the soil profile. The surface layer is a black or very dark grayish-brown silty clay loam, ranging from 14 to 18 inches in thickness, which overlies dark gray silty clay or silty clay loam. The gradation zone between the very dark surface horizon and the underlying dark gray layer is usually about 8 inches thick. Mottlings of rust-brown and yellowish-brown begin to appear in the transitional zone above the dark gray horizon, and they are abundant at depths of 30 or 36 inches. The soil material below 30 or 36 inches, in most places, is a light gray silty clay which is highly mottled, but layers of sand or silt may sometimes occur.

There are a number of small variations in the profile of Wabash silty clay loam. In many of the more depressed parts of the basin-like areas occupied by the soil type, the texture of the upper-most layer is a silty clay or clay. Occasionally, small ponds or marshy areas occupy the lowest-lying portions of Wabash silty clay loam. Cattails, sedges and other aquatic plants tend to occur in these ponded or marshy areas, and some organic matter has accumulated on the surface of the mineral soil material. Where the silty clay loam adjoins Wabash silt loam, the texture of all of the layers in the profile is lighter than described, and the same is true where the type merges with soils of the Cass series. A number of areas of other soil types too small to be shown on the map have been included with Wabash silty clay loam in some localities.

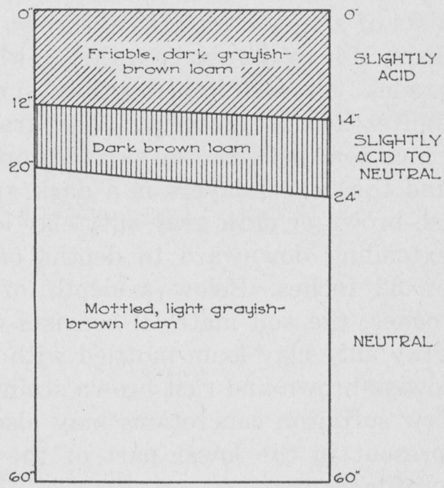
All of the areas of Wabash silty clay loam which are sufficiently well drained to be cultivated are now being farmed. The principal crop produced is corn, though a considerable acreage of wheat is also grown. Acre-yields of corn will range from 40 to 60 bushels and those of wheat from 15 to 30 bushels in favorable years. Small grains, particularly oats, are subject to some danger of lodging when grown on Wabash silty clay loam, and occasional damaged crops reduce the average yield obtained. Yields of small grains are distinctly lower on this soil type than on Wabash silt loam. Hay crops are not produced frequently on Wabash silty clay loam, but where clover-timothy mixtures are grown yields range from 1 to 1½ tons per acre. The highest yields of all crops are obtained in seasons with well-distributed but low rainfall.

Drainage is slow in all areas of Wabash silty clay loam because of the lack of slope and the impervious nature of the lower subsoil. The restricted drainage is often reflected in the nature of the crop during wet seasons; corn or small grains are stunted and become pale green or yellow in appearance. Removal of surplus water can be accomplished in a number of areas by the use of open ditches or tile, and either type of drainage improvement will be beneficial to subsequent crops. Incorporation of coarse residues of organic matter and the growing of deep-rooted plants should also be helpful in improving drainage conditions.

Wabash Loam (W) (49)

Wabash loam occupies 896 acres in the floodplains of the Skunk and Des Moines Rivers, thus making up 0.2 percent of the land in Marion County. The soil type is found chiefly in the form of long, narrow strips which lie near the channel of the stream and are often elevated slightly above the general level of the bottomlands. Individual areas range from 50 to 150 acres in size.

There is much variability in the profile of Wabash loam; its nature depends upon the position it occupies with reference to the stream channel and to other soils. The most generally occurring profile consists of three poorly defined layers or horizons: An upper layer of friable, dark grayish-brown loam, 12 or 14 inches deep; a second layer of a dark brown loam, 8 or 10 inches thick; and a mottled, grayish-brown or light grayish-brown clay loam. Much sand and some gravel is scattered through the different layers of the profile in most locations, and it is especially plentiful where Wabash loam borders Cass soils. All three layers of the soil profile are slightly acid in reaction.



WABASH LOAM

Variations in the profile of Wabash loam are chiefly those in the texture of the different layers. Where the soil borders the stream channel, all of the horizons of the profile are relatively light in texture, with the uppermost layer being a sandy loam. The heavier-textured bodies of the soil type generally lie some distance from the river bank. Near the river there are also a number of small mounds or ridges of yellowish-brown soils with sandy or gravelly lower horizons. These areas would have been mapped as members of the Cass series had they been large enough to show.

Most Wabash loam can be cultivated and is now used for the production of crops, corn being the chief one grown. Average acre-yields of corn range from 35 to 50 bushels in ordinary years, but the crop is always subject to damage from overflow because of the position of the soil near the river channel.

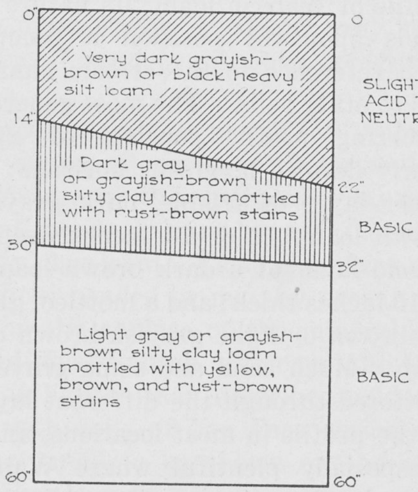
Wabash Silt Loam, Colluvial Phase[8] (Wl-x) (26a)

Wabash silt loam, colluvial phase, is the least extensive of the soils found in the bottomlands of Marion County, occupying only 192 acres in all. It occurs in upland drainageways and on a few sloping areas bordering the flood plains of smaller streams in the northwestern part of the region. Because of its very limited extent, the phase is of little

[8] As a result of further study and more complete knowledge, the soils formerly mapped as Wabash silt loam, colluvial phase, are now recognized as a complex or geographic association of two soil types, Wabash silt loam and Judson silt loam. Similar complexes are indicated as Wabash-Judson silt loam in more recent surveys.

agricultural importance even though it is highly productive.

The profile of Wabash silt loam, colluvial phase, consists of a very dark and deep surface horizon, an underlying dark gray or grayish-brown layer, and the transitional zone between them. The surface horizon consists of a very dark grayish-brown silt loam, 14 to 22 inches thick, which grades almost imperceptibly into lighter-colored material. The transitional zone between the surface horizon and the deeper layers is a dark grayish-brown or dark gray silty clay loam extending downward to depths of 30 or 32 inches. Below a depth of 32 inches, the soil material consists of a gray silty clay loam mottled with yellowish-brown and rust-brown stains. A few soft iron concretions may also be present in the lower part of the soil profile.



WABASH SILT LOAM
COLLUVIAL PHASE

Some variations in the texture of the surface layer may be found in areas of Wabash silt loam, colluvial phase. Sandy materials have been washed down from the uplands in a few places to give the uppermost horizons a texture lighter than a silt loam. Such variations are of little significance with regard to possible utilization and management.

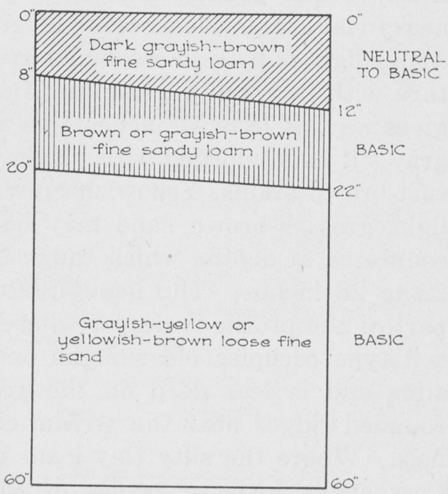
Natural drainage of the phase ranges from fair to good, since most areas of the soil occupy draws with slopes ranging from 3 to 5 percent. Runoff waters are carried away rapidly, and the danger of overflow is very small.

Wabash silt loam, colluvial phase, is better adapted to the production of corn and hay than small grains. Yields of the two former crops are as high as any obtained in the county, but small grains are subject to damage from lodging which tends to lower the average acre-yields. Yields of hay crops, especially clover-timothy mixtures, are much above the average production for the entire county.

Cass Fine Sandy Loam (Cy) (130)

Cass fine sandy loam occurs rather extensively in the bottoms of the Des Moines River and in one strip in the valley of the Skunk River. Areas of the soil type are usually separated from the river channel by gravelly or sandy Riverwash and from the uplands by bodies of Wabash soils. Individual bodies of the soil type range from less than one-eighth to more than a mile in width and from about 10 to 1,000 acres in size. The total acreage of Cass fine sandy loam comprises 1.0 percent of the land in Marion County. Most areas of the soil type are marked by slight irregularities in the generally smooth surface of the floodplain.

The profile of Cass fine sandy loam, as in many sandy soils, varies considerably from place to place. Commonly, the profile includes a friable dark grayish-brown, fine sandy loam surface horizon, 8 to 12 inches thick, grading through lighter-colored material of the same texture into grayish-yellow or yellowish-brown fine sand. Gravel is usually present in small quantities in all of the layers of the soil profile and may be present in large amounts in the underlying sediments. The profile is slightly acid or neutral in reaction throughout.



CASS FINE SANDY LOAM

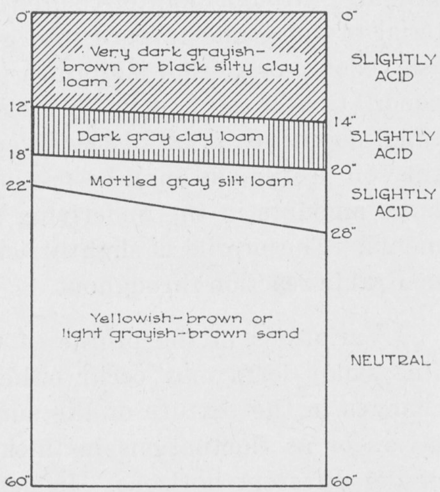
Variations in the profile of Cass fine sandy loam may occur either as changes in the texture of the surface layers or as fluctuations in thickness of the different horizons. In depressions or flat areas, the texture of the surface layer approaches a loam, and all of the layers are heavier and slightly darker. On the other hand, the surface layer of the soil on low ridges or mounds is an open, loamy sand which persists to depths of several feet. The depressional areas and the low ridges are intermingled, giving rise to the slightly irregular surface already mentioned.

The larger part of the total acreage of Cass fine sandy loam is under cultivation, even though much of it is subject to overflow whenever the rivers are high. Excess water from floods or heavy rains drains away rather quickly through the porous underlying materials, but the water table generally remains within the reach of plant roots. Crops do not suffer from a shortage of moisture in ordinary seasons. Corn and small grains constitute the principal crops with smaller acreages of hay. Yields of corn are much lower than the ones obtained on Wabash silt loam and range from 20 to 35 bushels per acre. Yields of small grains are comparatively better than those of corn, and this is particularly true of rye.

Cass Silty Clay Loam (Cc) (51)

Cass silty clay loam occurs in isolated bodies in the valley of the Des Moines River wherever heavy-textured materials overlie gravelly or sandy deposits. These isolated areas range in size from less than 40 to as much as 300 acres. There are, however, only a small number of areas, so that the total acreage of Cass silty clay loam is no more than 1 square mile.

Cass silty clay loam differs from the type of the same name in the Wabash series because of the sandier alluvium beneath the soil. The surface layer of the Cass profile consists of a dark grayish-brown or black silty clay loam, 12 or 14 inches thick, which grades into dark gray, heavy clay loam. The second layer becomes lighter both in color and in texture with increasing depth and finally gives way, at 18 or 20 inches, to a light gray silt loam mottled with yellow and rust-brown stains. Yellowish-brown or light grayish-brown sand may be encountered at depths which range from 22 to 28 inches. The heavy-textured part of the profile is deeper where the soil type occupies old sloughs or flat sites and is less deep on the gently rounded ridges near the stream channels. Where the silty clay loam joins Cass sandy loam or bodies of Riverwash, the surface layer of the soil has a loam texture.



CASS SILTY CLAY LOAM

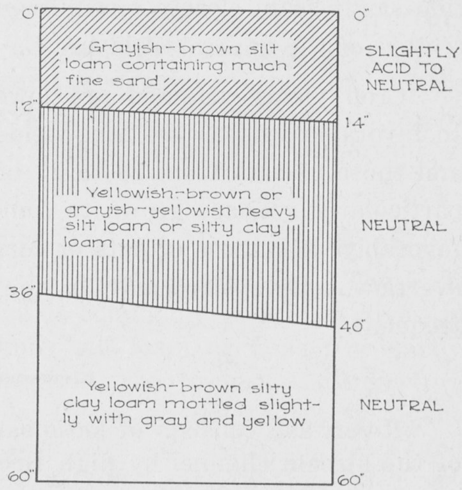
Drainage in areas of Cass silty clay loam is somewhat better than that in bodies of Wabash silty clay loam, being more nearly comparable to that in Wabash silt loam. The more rapid drainage of the Cass soils as compared to Wabash soils of similar texture is due to the underlying sand and gravel which is highly permeable. In some of the slightly depressed areas of Cass silty clay loam, however, drainage is restricted because of the slow downward percolation through the heavier textured, upper portions of the soil mass.

Heavy-textured Cass soils such as the silty clay loam are relatively fertile and produce yields comparable to the ones obtained on Wabash silt loam. The acre-yields of corn, which is the chief crop grown, range from 35 to 60 bushels and those of wheat range from 15 to 30 bushels. Clover-timothy mixtures grow quite well and yield from 1 to 2 tons per acre, but they are planted on only a limited acreage.

Genesee Silt Loam (G) (71)

The Genesee silt loam in Marion County occupies only 320 acres which occur in the form of narrow, disconnected strips near the borders of the Des Moines River valley. These strips have been developed where small streams come down from uplands covered by Clinton silt loam and other light-colored soil types. Light-colored alluvium derived from the forested, upland soils was carried down and deposited over parts of the floodplain. Most areas of light-colored soils in the bottomlands are small, and the largest single one of Genesee silt loam covers only 70 acres in the Des Moines River floodplain straight north of Knoxville.

The surface layer of the Genesee silt loam profile consists of a light grayish-brown silt loam which grades into yellowish-brown or grayish-yellow silty clay loam at depths of 12 or 14 inches. The second layer extends downward to 36 or 40 inches, below which stratified materials are often encountered. Some fine sand is present in all of the different layers of the soil, and mottlings of gray and dull yellow are present at and below depths of 30 or 34 inches. Where Genesee silt loam joins bodies of darker soils such as the Wabash or Cass series, the surface horizon of the profile is somewhat darker than the one described.

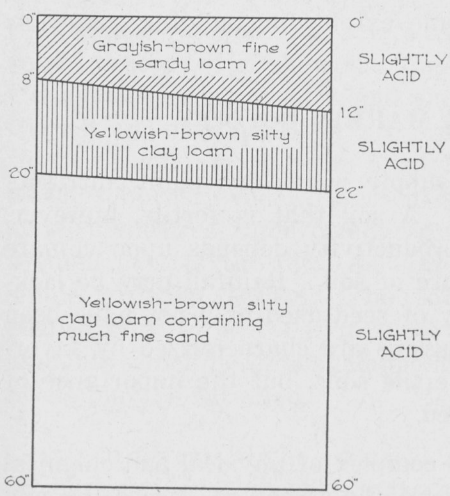


GENESEE SILT LOAM

Areas of Genesee silt loam are either flat or very slightly sloping, so that drainage is generally imperfect. Most of the soil type is being used for the production of crops without artificial improvement of drainage, and yields are somewhat lower than those obtained on Wabash silt loam.

Genesee Fine Sandy Loam (Ge) (117)

Genesee fine sandy loam occurs a little more extensively than the silt loam of the same series but in the same kind of locations. Bodies of the fine sandy loam occupy those parts of the floodplain which lie immediately adjacent to uplands covered by Lindley and Clinton soils. The alluvium from which the soil type is in process of formation was derived chiefly from the light-colored, surface horizons of the timbered soils of the uplands, but it contained larger proportions of fine sand than did the parent material of Genesee silt loam. Bodies of Genesee fine sandy loam are therefore more commonly found below outcrops of till materials. Individual areas of the soil type are seldom large, ranging in size from 20 to 160 acres, and the total acreage of the fine sandy loam in Marion County amounts to slightly less than 1 square mile.



GENESEE FINE SANDY LOAM

The upper layer of the Genesee fine sandy loam profile consists of a light grayish-brown fine sandy loam which gradually changes to brown or yellowish-brown silty clay loam at depths between 8 and 12 inches, below which stratified silty and sandy materials usually occur. Genesee fine sandy loam closely resembles the silt loam except for the different texture of the uppermost layer.

Crop yields obtained are lower than those on Genesee silt loam. In favorable seasons the acre-yields of corn range from 20 to 30 bushels and those of oats from 20 to 25 bushels. Small grains other than oats, particularly rye, are grown to some extent, and yields obtained compare favorably with those of oats or corn. Crops are occasionally damaged by overflow waters, especially in the spring, but floods are relatively infrequent.

Riverwash (Rv) (53)

Riverwash consists of loose sands and gravelly materials carried out of the stream channel by high floodwaters and deposited in strips ranging from 50 to 500 feet in width along the banks. This miscellaneous land type is found chiefly in the valley of the Des Moines River, but small areas also occur along the Skunk River channel and locally along the smaller creeks. Areas of Riverwash are subject to flooding almost every spring, are generally too coarse to retain sufficient quantities of moisture for plant growth and have little value either as crop or pasture land. The sand and gravel are utilized to some extent for building materials and for the surfacing of roads.

FERTILITY OF SOILS IN MARION COUNTY

A fertile soil has the capacity to supply water and plant nutrients in ample quantities to growing plants. A soil that is fertile, however, does not always produce good crops; productivity depends upon climate and management as well as on the nature of soil. Rainfall may be lacking and the crop will fail, or the variety of seed used may not have been disease resistant. Highly productive regions are characterized by favorable climatic conditions in addition to fertile soils, but the importance of the latter can scarcely be overemphasized.

The fertility of soil depends upon a complex of physical and chemical characteristics. Such properties as texture and structure, the nature and amounts of the various chemical compounds present, the distribution of the plant nutrients in the soil profile, the permeability and porosity of the soil mass and many more, determine the relative fertility of a soil. To illustrate: The capacity of soils to absorb, retain and furnish water to growing plants is governed largely by the texture and structure of the different horizons in the profile. Rain falling on either a granular silt loam or on a sandy loam, for example, will be readily absorbed. The silt loam, however, will retain larger quantities of water, and much of that water will be available for plant growth. Heavy-textured soils, such as clays, will also absorb large amounts of water if they have granular surface layers, but less of the absorbed water can be obtained by plants. If the surface layer of the soil does not have an open, porous structure but is compact and hard, water will not penetrate readily, and instead of being absorbed it will flow away over the surface and be lost. These examples illustrate only one of the ways in which the physical nature of soil may influence the growth of crop plants; it becomes important in many other ways as well.

The physical properties of the different soils occurring in Marion County have been discussed briefly in the preceding sections. The texture of the upper part of the soil which is commonly plowed is given in the soil type name: for example, Grundy silt loam or Cass fine sandy loam. The structure of the surface horizon, the texture and structure of the deeper layers of the soil profile, the color and thickness of the various horizons and the permeability of the soil mass to water and plant roots are described briefly in the text for each of the soil types.

Equally as important as the physical nature of soil in determining its fertility is the chemical nature of its components. The kinds and quantities of compounds present in the soil at any given time determine the amounts of the various plant nutrients that will be available to growing plants. The great bulk of the soil, of course, consists of chemical compounds which are not active as plant nutrients; they form the "framework" or "body" of the soil. Compounds such as silica, the principal constituent of ordinary sand, and alumina, which occurs in complex forms in the silt and clay fractions, are present in large amounts in most soils, but they are not important as nutrients for growing plants. Elements such as phosphorus, which are essential for plant growth, are present in very small quantities when compared to the total mass of the soil, and only a small part of the total amount present is available to plants during a single growing season. The total quantities of the various nutrient elements in the soil are of importance, however, because they affect the amounts which become available and serve as a reserve from which future needs may be satisfied.

In contrast to the physical properties of soils, many of which can be observed in the field without instruments, chemical characteristics must be described chiefly by means of laboratory studies. Partial chemical analyses have therefore been made of a number of samples of soils from Marion County. These analyses include the determinations of the total quantities of phosphorus, nitrogen and organic carbon present and the lime requirement of three different layers selected from the profiles of the various soils.

CONTENTS OF PLANT NUTRIENTS

Samples for partial analyses were collected from the profiles of 18 of the soil types and phases mapped in Marion County. Soils of very limited extent, such as Wabash loam, or those with poorly developed profiles, such as Clinton silt loam, shallow phase, were not sampled. A few of the more extensive soils were sampled at two or more locations in the county, and analyses were made of the samples from each location. The samples collected to represent the various soil types were taken in cultivated fields wherever possible, and an attempt was made to select fields that had not been limed or fertilized.

Three different layers, arbitrarily selected as to depth, are represented by the samples from each of the soils. The uppermost layer sampled corresponds approximately to the plow layer and lies between 0 and 6 2/3 inches; the second layer lies between 6 2/3 and 20 inches, immediately below plow depth; and the third and deepest layer sampled lies between 20 and 40 inches. These layers do not correspond to the horizons in the profiles of the different soil types, but in the Prairie soils, which lack sharply defined horizons, the results of arbitrarily selected layers can be indicative. More difficulty is encountered in the interpretation of analyses of samples from layers of considerable thickness in the profiles of the timbered or Gray-Brown Podzolic soils. In the discussion of the analytical results, the three different layers will be designated as the plow layer (0-6 2/3 inches), the subsurface layer (6 2/3 - 20 inches) and the subsoil layer (20-40 inches).

The analytical procedures followed include official methods for the determination of the total amounts of phosphorus, nitrogen and organic carbon and a qualitative test to estimate the approximate lime requirement. Duplicate determinations were made on the samples from each layer, and the values given in table 4 represent the average of two or more analyses. More than two analyses were averaged to obtain the figures given for the different layers of Grundy silt loam, Tama silt loam and Clinton silt loam.

The data in table 4 are tabulated so as to permit comparisons of the contents of the various elements in the different layers of the same profile or in comparable layers from different profiles. All values are expressed as pounds per 2 million pounds, which is the approximate weight of the furrow slice (0-6 2/3 inches) over an area of 1 acre. Figures given in the table represent the actual contents of phosphorus, nitrogen and carbon in the plow layer, one-half of the total quantity in the subsurface layer and one-third of the amount in the subsoil layer. It will be noted that the thickness of the second or subsurface layer is twice that of the plow layer, whereas the third or subsoil layer is three times as thick as the furrow slice.

The total amounts of phosphorus present in the surface layers of the soils of Marion County range from 498 to 1,320 pounds per acre. The content of phosphorus is as low as 498 pounds per acre in only one

TABLE 4. TOTAL CONTENTS OF PHOSPHORUS, NITROGEN AND ORGANIC CARBON AND LIME REQUIREMENTS OF THREE LAYERS AT DIFFERENT DEPTHS IN MARION COUNTY SOILS. ALL DATA ARE GIVEN AS POUNDS PER 2 MILLION POUNDS, THE APPROXIMATE WEIGHT OF A LAYER OF SOIL 6 2/3 INCHES DEEP OVER AN AREA OF 1 ACRE.

	Soil type and number	Phosphorus			Nitrogen			Organic carbon			Limestone requirement		
		0-6 2/3"	6 2/3-20"	20 - 40"	0-6 2/3"	6 2/3-20"	20 - 40"	0-6 2/3"	6 2/3-20"	20 - 40"	0-6 2/3"	6 2/3-20"	20 - 40"
					Dark-colored soils with free natural drainage								
120	Tama silt loam	883	801	888	2806	1940	1330	32,900	17,900	11,500	2000	1500	1000
264	Muscatine silt loam, slope phase.	1239	956	902	3764	3668	1672	42,404	30,316	15,871	2000	1000	1500
92	Shelby silt loam	929	835	2182	3520	2588	760	42,600	30,800	9,400	4000	2000	1500
110	O'Neill fine sandy loam	1041	934	866	1971	1229	729	23,160	12,427	7,267	1000	2000	1500
					Light-colored soils with free natural drainage								
80	Clinton silt loam	801	861	929	1662	1578	1226	27,365	18,025	10,567	1000	1000	1000
122	Clinton fine sandy loam	498	363	323	1124	400	208	15,625	4,145	2,772	2000	1000	0
261	Weller silt loam	1077	996	1037	3708	1048	760	38,914	9,708	6,545	2000	2500	2500
32	Lindley silt loam	848	498	485	2396	1236	684	24,816	13,771	7,254	2000	3500	3000
					Imperfectly drained soils of upland and terraces								
30	Muscatine silt loam	1272	1131	915	4090	3363	2018	51,785	43,309	23,725	5000	2000	1500
64	Grundy silt loam	1124	747	528	4126	2890	1598	53,776	40,945	20,261	2000	2000	1000
66	Putnam silt loam	875	646	633	3216	1864	1292	42,400	24,600	14,600	3000	1500	1000
88	Bremer silt loam	1239	929	787	5620	3128	1788	72,647	45,268	24,816	0	0	0
43	Bremer silty clay loam	969	592	606	3796	2312	1768	47,531	21,878	19,771	0	0	0
105	Chariton silt loam	902	713	754	3308	1312	952	39,568	16,580	12,462	4000	2000	1500
					Soils of the bottomlands								
26	Wabash silt loam	1320	1254	1306	2892	1884	1180	38,600	35,600	33,000	1000	1000	0
48	Wabash silty clay loam	996	431	1041	2112	3824	2641	32,000	50,200	40,200	1000	1000	0
130	Cass fine sandy loam	821	781	740	1152	924	552	12,991	9,704	4,697	0	0	0
71	Genesee silt loam	1077	998	835	2208	1580	1504	23,916	17,780	17,889	0	0	0

soil type, the Clinton fine sandy loam, and in most of the soils it falls between 800 and 1,200 pounds per acre. Soils which are imperfectly drained and are intermediate to heavy in texture generally contain more phosphorus than do the better drained or lighter-textured types. The differences with respect to the content of phosphorus in the plow layer are not marked, however, among the various soil types that occur in Marion County.

Comparing changes in the content of phosphorus within the profiles of the various soils, there is a tendency for the amount to decrease with increasing depth as far down as these soils were sampled. Reversals of this trend can be observed in six of the soils. Other investigations carried on by the Soils Subsection of the Iowa Agricultural Experiment Station have indicated that the content of phosphorus tends to fall off with increasing depth in the soil profile until it reaches a minimum, after which it increases appreciably. The lowest contents of phosphorus in the soil profiles have been found to occur at depths falling between 20 and 30 inches, and the largest amounts have sometimes been found in the deepest layers sampled, many of them at 55 or 60 inches. The tendency toward an increase in the total content of phosphorus at greater depths within the soil profile can be noted in the data for Tama silt loam, Shelby silt loam and Clinton silt loam in table 4.

It has already been indicated that data regarding the total amount of phosphorus, or any other element present in the soil, cannot be interpreted directly in terms of plant growth. To continue with the one example, but remembering that similar statements will apply to other elements also, the phosphorus available to plants at any given time will depend upon the forms present as well as the total quantity in the soil. Certain forms are readily available to plants, whereas others are difficulty soluble and can be utilized only to a limited extent. As a rule, only a small portion of the total amount of an element present in the soil occurs in a form available to plants, but unavailable forms of phosphorus, potassium and nitrogen in the soil slowly change into available forms. The total quantity of these elements present influences the rate at which they become available and limits the total amount that can be released. Soils such as Clinton fine sandy loam, for example, which contain relatively low quantities of phosphorus, cannot long supply that element to growing plants regardless of the rapidity with which it is released from unavailable to available forms.

Differences in the total contents of nitrogen in the plow layers of the soils of Marion County are larger numerically than those of phosphorus, ranging from 1,124 pounds per acre in Clinton fine sandy loam to 5,620 pounds per acre in Bremer silt loam. Bremer silt loam contains approximately five times as much nitrogen as Clinton fine sandy loam, whereas the other high-nitrogen soils have about three or four times as much of the element as Clinton and Cass fine sandy loams. Sandy soils are generally low in their content of organic matter and nitrogen as compared to those with intermediate or heavier textures. Similarly, well-drained soils are lower in their contents of nitrogen than are imperfectly or poorly drained soils. The imperfectly drained soils of the uplands and terraces of Marion County, considered as a group, contain distinctly larger quantities of nitrogen in the plow layers than do the soils of the other groups. They are followed in order of decreasing amounts of nitrogen by the groups of well-drained, dark-colored soils; the soils of the bottomlands and the well-drained light-colored soils.

If the contents of nitrogen in all three layers of the soils are considered, with particular emphasis on the amount in the subsurface layer, the well-drained, light-colored group of soils falls considerably below the others. The quantity of nitrogen in the surface layer corresponding to the thickness of the furrow slice is generally lower in the timbered or Gray-Brown Podzolic soils than it is in the Prairie and other dark-colored soil groups. Furthermore, the content of nitrogen drops off more sharply with increasing depth in most timbered profiles. These tendencies are indicated by the data given in table 4, but they are much more evident when the soil profile is sampled in layers which are but a few inches in thickness. The need for greater applications of organic matter and the growing of a larger proportion of legumes in the rotation to maintain and increase the contents of nitrogen in the light-colored soils of Marion County is emphasized by the figures given in table 4.

The quantities of organic carbon present in the different layers of the various soils tend to parallel those of nitrogen. The plow layer of Bremer silt loam contains more organic carbon than does that of any other soil, whereas carbon contents in the furrow slice of both Cass fine sandy loam and Clinton fine sandy loam are low. Nitrogen and carbon are two elements which exist in soils primarily as constituents of organic matter, which is largely responsible for their occurrence in parallel amounts. The actual quantities of organic carbon present in the plow layers of the different soils range from 12,991 pounds per acre in Cass fine sandy loam to 72,647 pounds per acre in Bremer silt loam. Amounts of carbon are approximately 12 times as large as those of nitrogen in the plow layers of these soils.

The intensity of the dark colors which can be observed in the soils of Marion County tends to be related to the amount of organic carbon present. The imperfectly drained soils which contain the largest quantities of carbon are darker than are the well-drained Prairie soils, which, in turn, are darker than the soils that were formed under forest vegetation. Differences in the colors of soil may arise from variations in the nature of organic matter as well as from differences in the total quantities present, but there is generally a relationship between the content of organic carbon and the color of the soil in the Prairie region.

In addition to determinations of the contents of phosphorus, nitrogen and organic carbon, the lime requirement of each of the different layers of these soils was also estimated. The lime requirements, expressed as pounds of limestone required to neutralize the acidity in 2 million pounds of soil, range from 0 to 2½ tons per acre. Most of the soils in Marion County are acid in reaction, as is indicated in table 4, but there are considerable variations in the actual acidity and lime needed within single areas of a soil type. Data as to lime requirements, therefore, are only meant to be indicative and should not be applied directly to a particular field. Ordinarily, it is desirable to determine the lime requirement on a number of samples selected to represent the various soils within one field and then apply limestone accordingly.

FIELD EXPERIMENTS

Trials of different treatments on experimental plots or fields have long been used as a means of finding out what might be needed to make soils more productive. This method is perhaps much older than is the use of chemical analyses of samples of soil to try to discover deficiencies. It will continue to be important for a long time to come, since full interpretation of the results of chemical analyses in terms of plant growth would require a complete knowledge of the nature of both plants and soils. Our knowledge of plants and soils is still incomplete, and because of their complex nature, it tends to grow rather slowly.

Experiments on soils in plots or fields have been made in Iowa to study the effects of soil amendments and the value of cultural practices. Most of these experiments have been concerned with the influences of different soil amendments; the trials discussed in the following paragraphs were limited to a study of the effects of manure, limestone and commercial fertilizers on the yields of crops. Data from three different soil types in as many different fields are presented in this report. None of these fields was located in Marion County, but the results obtained on Grundy silt loam in Wapello County, for example, will be applicable to the same soil type in the former area. Data are reported from experiments on three soil types: Tama silt loam, Grundy silt loam and Clinton silt loam. If a soil type occurs over a wide geographic range, as does Tama silt loam, data were taken from fields near Marion County so that conditions would be comparable. The conclusions drawn from the results obtained on these three soil types can be applied to other similar soils in the county.

Information obtained from the experiments is given in the form of summary tables which represent all of the data on crop yields and increases in yield following treatment from plots in one or more fields on each soil type. In addition to the summary tables, the crop yields from individual plots by years on Tama silt loam in one field are also presented. The annual records illustrate the fluctuations in yield or in effect of treatment that may accompany changes in weather conditions or other external factors which influence productivity. Fluctations similar to the ones noted on Tama silt loam also will occur on other soils.

Before discussing the results obtained in the trials with manure, lime and fertilizer on the three soil types, the methods followed in the experiments will be described briefly. Arrangements are first made with the owner of a field for the establishment of a series of plots on an area of a particular soil type, the area being selected as representative of the type in profile characteristics, topography, drainage and other physical factors. After the area is selected, the outside boundaries of the series of plots are marked by iron stakes driven into the ground along the edge of the field. Nine plots were laid out in each of the newer fields and 13 plots in each of the older fields, three in each group serving as check plots without treatment. Individual plots are indicated each year by temporary wooden stakes.

The entire field is farmed in the usual way by the operator, and the plots receive no special handling except the applications of manure, fertilizer and lime. The additions of manure, limestone and various commercial fertilizers are made by a fieldman of the Iowa Agricultural Experiment Station, who also inspects the plots from time to time during the growing season to note the condition of the crop, any damage that may be done by insects or hail, abnormalities in growth, etc. In the fall the fieldman harvests samples of the crop from each plot and records the yields. These yields are usually expressed as pounds per plot and are later converted so as to read in bushels or tons per acre.

The experiments have included trials with manure, limestone, rock phosphate, superphosphate, mixed fertilizers (sometimes called complete fertilizers) and muriate of potash. All of the different treatments, however, have not been used in every field. In some of the older fields, one series of plots did not receive applications of barnyard manure, whereas the addition of manure is considered a basic treatment in the newer fields. In these newer fields manure is added to all except the check plots, and other treatments are then superimposed. For example, limestone alone or limestone and some form of commercial fertilizer are applied to a plot in addition to barnyard manure.

Manure has been applied at the same rate throughout the duration of these experiments. Additions have been made at the rate of 8 tons per acre once every 4 years, a period corresponding to the length of the average rotation being followed. On the unmanured series of plots in the older fields, additions of organic matter consisted only of the crop residues that were left after harvest. Sometimes the second cutting of clover or mixed hay was left to be plowed under as green manure on the plots receiving crop residues only.

The lime requirement of the soil in each of the plots has been determined once during each 4-year period and enough limestone added to neutralize the acidity.

Commercial fertilizers used included rock phosphate, superphosphate, mixed fertilizers and muriate of potash. Rock phosphate was applied at the rate of 1 ton per acre once each 4 years prior to 1925, when the rate was reduced to 1,000 pounds per acre. Since 1932, the rate of application has been reduced once more, this time to 500 pounds per acre. Additions of 16 percent superphosphate at the rate of 200 pounds per acre were made in each year that legumes did not occupy the plots prior to 1924. The application rate was reduced to 150 pounds per acre in 1924, and 20 percent superphosphate was substituted for the 16 percent fertilizer in 1929. The 20 percent superphosphate has been applied at the rate of 120 pounds per acre since 1929.

Commercial mixed fertilizer, consisting of a 2-8-2 mixture[9], was applied at the rate of 300 pounds per acre annually, except when the plots were in a legume crop, in the earlier experiments. From 1923 to 1929, a 2-12-2 mixture was added in amounts equivalent to 150 pounds of 16 percent superphosphate. In 1929, this mixture was replaced by a 2-12-6 mixture, applied at the same rate per acre.

Muriate of potash has been added at the rate of 50 pounds per acre since 1934, and applications were made each year that legumes were not being grown. Prior to 1934, additions of the muriate were made at the rate of 25 pounds per acre, and no potash fertilizers were applied in the year that a legume crop occupied the plots.

Experiments on Tama Silt Loam

The average yields obtained and the increases which followed different treatments on Tama silt loam in central and south-central Iowa are given in table 5. These data were summarized from the yields of corn, oats and clover grown on fields in Jasper, Madison and Marshall Counties. Average yields and increases in yield of clover are less apt to be reliable than are those of oats and corn, since only four crops of clover were harvested from the three fields.

The average yields of the three different crops were all somewhat higher after the various treatments, but distinctly larger responses were obtained with oats and clover than with corn. The largest single increase after treatment followed the application of manure, limestone and mixed commercial fertilizer to oats. This maximum increase in the yield of oats was 16.6 bushels per acre, or nearly 38 percent of the check plot yield. The total yield of the oat crop was increased approximately 10 percent after the application of manure, an additional 10 percent when limestone was also applied and a third 10 percent when some form of phosphorus was added. The yields of clover also indicate a marked response on the part of that crop to the application of some form of phosphorus, a smaller increase after the addition of manure and apparently no response to the application of limestone. The maximum increase in the yield of clover amounted to 27 percent of the yield from the check plots. Yields of corn were increased slightly more than 8.5 percent by the application of manure alone, with the largest individual response amounting to an increase of 14 percent following the addition of manure, limestone, superphosphate and muriate of potash. None of the increases in the yield

[9]Figures refer to percentages of nitrogen, phosphoric acid and potash, respectively.

TABLE 5. AVERAGE ACRE-YIELDS OF CROPS AND INCREASE FOLLOWING FERTILIZER TREATMENTS ON TAMA SILT LOAM.*

Treatment	Corn[1] bu. per acre		Oats[2] bu. per acre		Clover[3] tons per acre	
	Average yield	Increase	Average yield	Increase	Average yield	Increase
Check	59.2[4]	----	44.0[4]	----	1.46[4]	--
Manure	64.3	5.1	48.8	4.8	1.60	.14
Manure + limestone	65.9	6.7	52.9	8.9	1.60	.14
Manure + limestone + rock phosphate	67.2	8.0	55.2	11.2	1.86	.40
Manure + limestone + superphosphate	66.8	7.6	58.2	14.2	1.79	.33
Manure + limestone + superphosphate + potassium	67.5	8.3	55.9	11.9	1.78	.32
Manure + limestone + complete commercial fertilizer	65.6	6.4	60.6	16.6	1.70	.24

[1]Corn yields are the average of 16 crops on 3 fields.
[2]Oats yields are the average of 6 crops on 2 fields.
[3]Clover yields represent the average from 4 crops on 2 fields.
[4]Average yield from check plots for all of crops grown.
*Data were summarized from records of Newton field, Series I, Jasper County; Winterset field, Series I, Madison County, and LeGrande field, Series I, Marshall County.

of corn is large, and only small differences exist between the responses to the various treatments. Applications of manure alone, therefore, seem to be as beneficial to corn as do the additions of manure, limestone and commercial fertilizers together.

The summarized data in table 5 indicate the general trends that can be expected from the different treatments when carried out on Tama silt loam in south-central Iowa. Only general trends can be indicated, however, partly because of fluctuations in weather conditions and consequent variations in the effect of fertilizer treatments from year to year and partly because of variations in the characteristics and productivity of a soil type from one place to another. Many of the experimental plots have been laid out on areas better than average for the soil type in fields operated by good farmers. Smooth or nearly level sites have usually been selected so as to obtain larger areas of uniform soil conditions, and these are not always representative of the soil type as a whole. Summary tables cannot present the fluctuations in yield that may occur from year to year. In order to provide a picture of the yearly variations in yield that may occur, the crop yields obtained each year from the individual plots in a field near Winterset, Madison County, are presented in table 6. The plots in the Winterset field are located on Tama silt loam, and the experiments reported were carried out during the years 1922 to 1936, inclusive.

The crop yields given in table 6 indicate some of the variations in total return and in the effect of treatment that may follow as a result of changes in seasonal conditions. First of all, it is readily apparent that much larger ranges in yield occur because of changes in weather conditions

TABLE 6. FIELD EXPERIMENT ON TAMA SILT LOAM, WINTERSET FIELD*, SERIES I, MADISON COUNTY.

Plot No.	Treatment	1922 Corn[1] bu. per A.	1923 Corn bu per A.	1924 Oats bu. per A.	1925 Clover tons per A.	1926 Corn bu. per A.	1927 Corn bu. per A.	1928 Corn bu. per A.	1929 Oats bu. per A.	1930 Timothy & clover, tons per A.	1931 Corn bu. per A.	1932 Corn bu. per A.	1933 Oats[2] bu. per A.	1934 Clover[3] tons per A.	1935 Alfalfa[4] tons per A.	1936 Alfalfa[5] tons per A.
1	Check	77.1	43.9	54.8	1.50	56.8	55.0	60.5	61.3	1.85	55.9	74.7	22.1	----	----	1.60
2	Manure	77.2	46.6	59.2	1.58	----	57.6	59.5	59.0	2.11	53.4	77.8	20.4	----	----	2.17
3	Manure + limestone	76.1	47.2	67.1	1.60	56.8	54.8	62.4	65.9	2.03	56.4	77.7	24.1	----	----	3.28
4	Manure + limestone + rock phosphate	76.5	50.4	71.6	1.76	59.7	61.0	69.1	64.6	2.26	55.3	80.1	23.0	----	----	3.62
5	Check		45.1	55.9	1.54	52.5	53.6	58.9	54.5	1.75	53.9	74.4	19.3	----	----	1.77
6	Manure + limestone + superphosphate	79.7	49.8	67.6	1.61	53.0	57.9	64.8	68.1	2.45	56.3	80.8	27.2	----	----	3.42
7	Manure + limestone + super-phosphate + muriate of potash	81.0	50.9	65.5	1.63	55.0	60.0	62.9	67.0	2.33	55.7	82.5	25.5	----	----	3.40
8	Manure + limestone + complete commercial fertilizer	72.1	52.0	68.2	1.55	51.5	51.1	63.5	68.1	2.20	54.7	80.9	26.1	----	----	3.31
9	Check	72.7	43.9	52.6	1.54	46.4	47.8	63.7	56.8	1.84	51.8	75.5	20.0	----	----	1.66

[1]Limestone not applied until 1923.
[2]Hot, dry weather in June and July seriously damaged oats.
[3]Poor stand due to drouth; field pastured.
[4]Alfalfa seeded alone. No harvest in 1935.
[5]Total of 2 cuttings. Second cutting short and thin due to drouth.

*The Winterset Field, Series I, was established in the fall of 1921 on the J. T. Williams farm, northwest of Winterset in Madison County, and it was discontinued in 1937. It was located in the SW¼ of the NE¼ of Section 23, T.76N., R.28W., Douglas Township.

from one year to another than were brought about by the different treatments. The yields of corn from the check plots range from a minimum of 43.9 buhels per acre in 1923 to a maximum of 77.1 bushels in 1922. The highest corn yield—82.5 bushels per acre—from any single plot during the experiment was obtained from the one receiving manure, limestone, superphosphate and muriate of potash in 1932, and in that same year 74.9 bushels per acre, on the average, were harvested from the check plots. The smallest crop of corn harvested from the plot receiving muriate of potash in addition to other fertilizers was 50.9 bushels per acre in 1923. The range in the yield of oats is even larger than that of corn, apparently because oats were being grown in 1933, a particularly dry year. The lowest yield of oats harvested from any plot was 19.3 bushels per acre in 1933, whereas the highest yield obtained from the check plots was 61.3 bushels per acre in 1929. The maximum increase following treatment, comparing yields of oats from individual treated plots with the average from untreated plots was 17.3 bushels per acre in 1924.

As a general rule, increased yields followed the various treatments of Tama silt loam, but this is not invariably true. In some years, 1928 and 1931 for example, the yield of corn from the manured plot was no higher than the average yield on the untreated plots. Lower yields from the treated plots than from the checks are of infrequent occurrence among the data given in table 6, but the increases in yield are often so small as to lack significance. Differences of 2 or 3 bushels per acre in the yields from different plots cannot be considered as having meaning unless such differences can be observed consistently over a long period of time.

Variations in the effect of manure, lime or fertilizer treatments must be expected from time to time. Applications of manure or any other soil amendment seldom benefit crops in a dry year, and they may even be detrimental. Considered from the long-time point of view, however, treatment of the soils of the Prairie, Gray-Brown Podzolic and associated groups with manure, limestone and fertilizers is necessary if fertility is to be maintained.

Experiments on Grundy Silt Loam

The average yields obtained and the increases in yield following the different treatments of Grundy silt loam in five fields in southern and southeastern Iowa are given in table 8. The five fields are located in Mahaska, Wapello and Wayne Counties, with three fields in Wapello County and one in each of the others. Crops for which data are reported include corn, oats, wheat and clover. The data presented in table 8 have been averaged from a greater number of harvests than the values given in the other tables, and they are consequently somewhat more reliable.

In general, the crops grown on Grundy silt loam showed more consistent responses to treatment than did those on Tama silt loam. These more consistent responses may, of course, be due in part to the fact that more individual crop yields have been considered in obtaining the averages given in table 8. Smaller variations in the harvested yields from year to year

TABLE 7. AVERAGE ACRE-YIELDS OF CROPS AND INCREASE FOLLOWING FERTILIZER TREATMENTS ON GRUNDY SILT LOAM.*

Treatment	Corn[1] bu. per acre		Oats[2] bu. per acre		Wheat[3] bu. per acre		Clover[4] tons per acre	
	Av. yield	Increase	Av. yield	Increase	Av. yield	Increase	Av. yield	Increase
Check	60.4[5]	--	45.8[5]	--	25.4[5]	--	1.41[5]	--
Manure	64.0	3.6	58.1	12.3	26.9	1.5	1.79	.38
Manure + limestone	70.2	9.8	55.8	10.0	28.7	3.3	2.05	.64
Manure + limestone + rock phosphate	70.5	10.1	58.1	12.3	33.1	7.7	2.28	.87
Manure + limestone + superphosphate	70.4	10.0	60.7	14.9	34.8	9.4	2.27	.86
Manure + limestone + complete commercial fertilizer	70.8	10.4	56.4	10.6	34.1	8.7	2.51	1.10

[1]Corn yields are the average of 23 crops on 5 fields.
[2]Oat yields are the average of 19 crops on 5 fields.
[3]Wheat yields are the average of 11 crops on 5 fields.
[4]Clover represents the average from 8 crops on 3 fields.
[5]Average yield from check plots for all of crops grown.
*Data were summarized from records of Farson field, Series II, Wapello County; Corydon field, Series I, Wayne County; Agency field, Series I, Wapello County; Farson field, Series IV, Wapello County, and Cedar field, Series I, Mahaska County.

are to be expected, however, on a soil type such as the Grundy silt loam which tends to be quite uniform over fairly large areas.

A relatively small increase in the yield of corn followed the application of manure alone, whereas the larger increase associated with the addition of limestone plus manure equalled those obtained by the additional application of commercial fertilizers. Increases in the yield of corn of approximately 10 bushels per acre, or one-sixth of the average check plot yield, followed all of the treatments which were superimposed on the application of manure.

The response of oats to treatment is somewhat greater than that of corn, with a maximum increase of 14.9 bushels per acre or almost one-third of the check plot yield. The data indicate that oats responded very definitely to the applications of manure alone and that further treatment did not increase the yield very much. It will be noted that oats responded markedly to the application of manure, whereas corn did not. Ordinarily, corn requires larger amounts of nitrogen than oats, and is more often benefited by applications of barnyard manure. The increased yield of oats on Grundy silt loam following the addition of barnyard manure is only slightly smaller than that after applications of limestone or commercial fertilizer plus the manure. With the possible exception of superphosphate, commercial fertilizers did not seem to increase the yield of oats on Grundy silt loam.

The yield of wheat was apparently increased slightly by the application of manure alone, a little more by the further addition of limestone, and quite distinctly when phosphate fertilizers were also applied. Increases amounting to one-third of the average harvest from the check plots were obtained following three of the different treatments. Each of the different

TABLE 8. AVERAGE ACRE-YIELDS OF CROPS AND INCREASE FOLLOWING FERTILIZER TREATMENTS ON CLINTON SILT LOAM.*

Treatment	Corn[1] bu. per acre		Oats[2] bu. per acre		Clovers[3] tons per acre	
	Average yield	Increase	Average yield	Increase	Average yield	Increase
Check	34.9[4]	--	24.3[4]	--	.62[4]	--
Manure	44.0	9.1	32.9	8.6	.88	.26
Manure + limestone	51.8	16.9	42.8	18.5	1.43	.81
Manure + limestone + rock phosphate	55.4	20.5	44.9	20.6	1.47	.95
Manure + limestone + superphosphate	58.3	23.4	45.4	21.1	1.94	1.32
Manure + limestone + superphosphate + potassium	61.1	26.2	47.1	22.8	2.19	1.57
Manure + limestone + complete commercial fertilizer	57.9	23.0	44.0	19.7	1.73	1.11

[1]Corn yields are the average of 9 crops on 2 fields.
[2]Oat yields are the average of 6 crops on 2 fields.
[3]Clover yields represent the average from 3 crops on 2 fields.
[4]Average yield from check plots for all of crops grown.
*Data were summarized from records of Lockridge field, No. 2, Series I, Jefferson County, and Keosauqua field, Series I, Van Buren County.

phosphate applications brought about increases in yield of more than 25 percent of the average from the checks.

Larger increases in yield followed fertilizer treatment of clover crops than occurred with any of the others. The amount of clover harvested was increased from 1.41 tons per acre on the check plots to 2.51 tons per acre when manure, limestone and mixed commercial fertilizer were all added. Progressively larger increases, however, can be noted when manure, limestone and phosphate fertilizers are applied successively. If the response to one individual treatment is considered, that due to the addition of barnyard manure seems to be as large as, if not larger than, any other.

Experiments on Clinton Silt Loam

The average yields obtained and the increases following treatment on Clinton silt loam in two fields in southeastern Iowa are presented in table 9. The two fields are located in Jefferson and Van Buren Counties, both lying southeast of Marion County. Data given in table 9 were summarized from the yields of corn, oats and clover; crops grown only once on one field or the other have not been included.

As indicated by the data in tables 5, 7, 8 and 9, crops grown on Clinton silt loam showed greater response to soil treatment than did those grown on any of the other three soil types. Maximum increases in yield on Clinton silt loam, expressed as percentage of the check plot harvest, were 77, 94, and 250 percent for corn, oats and clover, respectively. Very marked increases in yield followed all treatments on all crops grown on Clinton silt loam.

The yields of corn on Clinton silt loam were increased 26 percent when manure was applied, an additional 22 percent when limestone was also applied, and as much as 77 percent in all when manure, limestone, and potash were added to one plot. Applications of rock phosphate, superphosphate or mixed commercial fertilizer with the manure and limestone increased the yield of corn considerably above that which followed the addition of manure and limestone. A slight additional increase in the yield of corn seems to have followed the application of muriate of potash.

Treatments increased the yields of oats more than the yields of corn, considered on a percentage basis, although the actual increases in bushels per acre were smaller. The oat crop harvested from the check plots was 10 bushels per acre smaller than that of corn. The general trend in the response of oats on Clinton silt loam to soil amendments is essentially similar to that already noted with corn. Further increases in yield follow each of the additional applications as they are included in the treatment.

The response of clover to the various soil amendments is somewhat different from those of the two other crops grown on Clinton silt loam. Application of manure alone increased the yield approximately one-third, whereas the further addition of limestone almost doubled the total harvest as compared to the check plots. A small additional increase occurred when rock phosphate was applied with the manure and limestone, and marked response to applications of superphosphate is indicated, with the average yield being increased to 1.94 tons per acre. The addition of muriate of potash with the superphosphate, manure and limestone raised the total yield to 2.19 tons per acre, which is about 3½ times that of the check plot. No particular beneficial effect from the use of mixed commercial fertilizer is noticeable when comparing the effects of its application with that of superphosphate on yields of clover. The same conclusions follow from inspection of the data for oats and corn.

The greater responses of crops to various soil amendments on Clinton silt loam are directly related to the nature of the soil. The Clinton and other light-colored soils were formed under timber vegetation; they have been more completely leached than soils formed from similar parent materials under prairie vegetation during the same interval of time, and they are somewhat lower in their contents of organic matter than are the Prairie soils. Because of the lower contents of organic matter, crops on Clinton silt loam respond more markedly to its addition in the form of barnyard manure. In the same way, the response of crops to applications of limestone and commercial fertilizers is related to the greater degree of leaching which has taken place. More care, both in cultivation and in the use of manure and fertilizers, is necessary to maintain or increase the productivity of the timbered (Gray-Brown Podzolic) soils than the Prairie or Prairie-like soils.

MANAGEMENT OF SOILS IN MARION COUNTY

Farmers in all regions are interested in obtaining high yields of crops, but such yields only follow when all of the factors which govern productivity are favorable. The right combination of many elements of climate, soil and management—to mention a few of the important general factors affecting productivity—are needed to produce even a poor corn plant, and still more right combinations are necessary to produce a good one. Among the various factors which govern agricultural production, management is the one over which the individual farmer can exercise the greatest degree of control. Elements of climate such as rainfall or the nature of the soil on the farm cannot be readily changed; such factors must be used to best advantage as they occur. Considerable variations in soil management are possible, however, within a group of farms of the same type on similar soil. These variations may bring about large differences in the quantity and quality of crops produced. Various desirable and undesirable management practices, as related to the soils of Marion County, are therefore discussed in this section of the soil survey report.

Satisfactory crop yields are now being obtained from many of the better, dark-colored soils in Marion County. These dark-colored soils, either members of the Prairie group or Prairie-like in nature, are relatively fertile and productive when first plowed, and they tend to remain productive for a considerable period of time. At the present time, however, better management of these soils will improve the quality of the crops being grown and will increase the yields obtained in many instances.

In contrast to the dark-colored soil types of the level and gently rolling areas, the light-colored soils and those in sharply rolling or hilly areas require careful management if they are to remain in production. The light-colored soils, as a rule, contain smaller quantities of organic matter than do the darker-colored types in Marion County, and they have been more deeply and thoroughly leached. More general applications of lime, manure and fertilizers are necessary if satisfactory crop yields are to be maintained. Longer rotations with a smaller proportion of corn and a larger share of legumes and grasses are also desirable. Similar conclusions will apply to the soils in sharply rolling or hilly areas, particularly where the profiles are shallow. The more rolling lands can often be used to best advantage as pasture or woodland, but where they are cultivated long rotations with frequent applications of organic matter, lime and fertilizer should be included in the system of soil management being followed.

Much information as to the kind of soil management necessary for best results on different soil types is now available to farmers. Some types of management necessary to obtain satisfactory production from a given soil may not fit into the farming scheme of a given unit, however, and alternative methods must be followed. Questions as to the more desirable kinds of soil management come up continually on farms, and they must be met immediately according to the nature of the soil and the organization of the operating unit. A discussion of the different possible methods of managing the soil will not eliminate the need for decisions on the part of the farm operator, but it should be of help in the making of choices between alternative practices. The various types of soil management recommended in this section are based on talks with farmers regarding their more successful practices, on field observations made in Marion County and on the results obtained in field and laboratory studies of the Iowa Agricultural Experiment Station. The practices suggested may be adopted on an ordinary farm with little difficulty, on the whole, and with the assurance of satisfactory results under normal seasonal conditions. Different phases of soil management are discussed under the following headings: Crop Rotations, Liming, Maintaining Organic Matter, Tillage and Erosion Control, Drainage and Use of Commercial Fertilizers.

CROP ROTATIONS

The value of crop rotations as one measure in the maintenance of high yields is now generally recognized. Even such simple rotations as the alternating of corn and oats, for instance, results in better yields of both crops than does the continuous growing of either. Nevertheless, there is a tendency to grow a larger proportion of intertilled crops in the rotation than is desirable for the maintenance of fertility. The continuous or often repeated growing of corn or other intertilled crops will eventually bring about a lowering of the content of organic matter and plant nutrients and a gradual deterioration of soil structure. To offset this tendency, it is necessary that certain other types of crops, notably the legumes and grasses, be included in crop rotations. These crops have a beneficial effect upon the soil and leave it in better condition for succeeding crops even though they themselves may not bring as large a cash return.

No one rotation will be generally adaptable to all of the soils in Marion County or even to all areas of one soil type as it may occur in different farms. Different areas of a particular soil type may differ in their productivity because of variations in soil characteristics or differences in the past management of the land. Furthermore, crop rotations have to be adapted to the needs of a farm unit as well as to the particular soil type. The rotation that could be followed on a well-stocked, well-equipped farm might not be feasible on another farm with less livestock and less machinery. Obviously, all of these considerations and many others are involved in the selection of crop rotations for a particular field or farm.

Although no experiments with rotations have been carried out in Marion County, some rotations may be suggested that will prove to be of value on the different soil types. As has already been suggested, these are not meant to be followed strictly but must be developed to fit the conditions within a particular farm or operating unit.

Rotations for the Dark-Colored Soils in Flat to Gently Rolling Areas

1. Six-year rotations

First year—Corn
Second year—Soybeans or corn
Third year—Small grain
Fourth year—Alfalfa
Fifth year—Alfalfa
Sixth year—Alfalfa

2. Five-year rotations

First year—Corn
Second year—Soybeans or corn
Third year—Small grain
Fourth year—Mixed hay*
Fifth year—Hay or pasture

First year—Corn
Second year—Corn or soybeans
Third year—Small grain
Fourth year—Alfalfa
Fifth year—Alfalfa

3. Four-year rotations

First year—Corn
Second year—Corn
Third year—Small grain
Fourth year—Mixed hay

First year—Corn
Second year—Oats (with clover)
Third year—Clover
Fourth year—Winter wheat (with sweet clover)

First year—Corn
Second year—Soybeans
Third year—Small grain
Fourth year—Clover

First year—Corn
Second year—Small grain
Third year—Mixed hay
Fourth year—Hay or pasture

4. Three-year rotations

First year—Corn
Second year—Small grain
Third year—Mixed hay

First year—Corn or soybeans
Second year—Small grain
Third year—Clover

First year—Corn
Second year—Small grain (with sweet clover)
Third year—Sweet clover (for pasture or green manure)

Rotations for Light-Colored Soils in Smooth or Gently Rolling Areas

1. Six-year rotations

First year—Corn
Second year—Corn or soybeans
Third year—Small grain
Fourth year—Mixed hay or alfalfa
Fifth year—Hay or pasture
Sixth year—Hay or pasture

First year—Corn
Second year—Small grain
Third year—Mixed hay or alfalfa
Fourth year—Hay or pasture
Fifth year—Hay or pasture
Sixth year—Hay or pasture

2. Five-year rotations

First year—Corn
Second year—Small grain
Third year—Mixed hay or alfalfa
Fourth year—Hay or pasture
Fifth year—Hay or pasture

First year—Corn
Second year—Corn or soybeans
Third year—Small grain
Fourth year—Mixed hay
Fifth year—Hay or pasture

3. Four-year rotations

First year—Corn
Second year—Small grain
Third year—Mixed hay
Fourth year—Hay or pasture

First year—Corn
Second year—Corn or soybeans
Third year—Small grain
Fourth year—Mixed hay

First year—Corn
Second year—Small grain (with clover)
Third year—Clover
Fourth year—Winter wheat (with sweet clover)

4. Three-year rotations

First year—Corn
Second year—Small grain (with sweet clover)
Third year—Sweet clover (for pasture or green manure)

First year—Corn or soybeans
Second year—Small grain
Third year—Mixed hay

*Mixed hay is meant to include all legumes and grass mixtures

Rotations for More Rolling Lands

1. Six-year rotations

First year—Corn
Second year—Small grain
Third year—Mixed hay
Fourth year—Hay or rotation pasture
Fifth year—Rotation pasture
Sixth year—Rotation pasture

First year—Corn
Second year—Small grain
Third year—Alfalfa
Fourth year—Alfalfa
Fifth year—Alfalfa
Sixth year—Alfalfa

2. Five-year rotations

First year—Corn
Second year—Small grain
Third year—Mixed hay
Fourth year—Hay or pasture
Fifth year—Pasture

First year—Corn
Second year—Small grain
Third year—Winter wheat
Fourth year—Mixed hay
Fifth year—Pasture

3. Four-year rotation

First year—Corn
Second year—Small grain
Third year—Mixed hay
Fourth year—Pasture

LIMING

The chief crops produced in Marion County make their best growth on soils which are only slightly acid in reaction. Some crops, such as soybeans, are rather tolerant of acid conditions, but others such as alfalfa and sweet clover, of particular importance in a program for maintaining soil fertility, do not thrive on soils that are even moderately acid. Alfalfa and sweet clover, and other legumes to a lesser extent, grow most successfully on soils which are either neutral or slightly acid in reaction. Since many of the soils in humid regions are acid, it is generally necessary to overcome this acidity before the best crops can be produced. The application of lime, commonly in the form of finely ground limestone, is the usual practice in overcoming soil acidity. Applications of lime must be made according to the degree of acidity of the soil, the nature of the crop and the general needs of the farm.

The soils of Marion County are predominately acid, ranging from moderately to strongly acid in reaction with but few exceptions. Most of the soil types are acid both in the upper layers of the profile and in the deeper horizons, and this is particularly true of the light-colored soils and those with well-developed claypan horizons. Light-colored soils such as Weller silt loam and the claypan soils such as Putnam silt loam are distinctly more acid in reaction, on the whole, than are the darker-colored soils. Well-drained, dark-colored soils, such as Tama silt loam, usually are moderately acid in the upper horizons and slightly acid in the deeper layers of the profile. The dark-colored, imperfectly drained soil types, such as Muscatine silt loam, are also moderately acid in the surface layers but are commonly neutral in reaction in the deeper subsoil. Differences in the degree of acidity, especially in the surface layers, exist within individual areas and between different bodies of most of the soil types.

A few soils in Marion County are occasionally neutral or slightly alkaline in reaction. Individual areas of Wabash silty clay loam or Bremer silty clay loam, both of which occupy depressional positions below the level of the upland, are sometimes neutral or slightly alkaline at the surface and are commonly neutral or alkaline in the deeper horizons. Areas of soils on the steeper valley slopes may also have neutral or alkaline surface layers. Wherever strata of limestone or calcareous shale outcrop at the surface in bodies of Clinton silt loam, shallow phase, or where lime (calcium carbonate) occurs near the surface of Lindley or Shelby soils, the upper layers of the shallow profiles are neutral or alkaline. These soils, usually found on steep valley slopes, range from moderately to slightly acid in reaction, but occasional local areas which are not acid do occur. The practice of liming is not generally followed on steeper lands not suitable for cultivation.

The amount of lime that is to be applied is determined largely by the acidity of the surface layers of the soil, but it may be governed in part by the lime requirement of the deeper horizons of the profile. If a soil which is acid in the surface layer contains lime that can be reached by plant roots, applications of lime need only be heavy enough to permit the plant to become established and develop a good root system. If, however, the soil is acid throughout its entire profile, enough lime must be added to the surface layers to satisfy the needs of the crop that is to be grown.

The quantity of lime required to neutralize acidity depends upon the reaction, texture and content of organic matter of the soil. More lime is needed to overcome acidity in a strongly acid silt loam than in a moderately acid silt loam. More lime would also be required to neutralize acidity in a clay loam than in a fine sandy loam, if both had the same reaction. Similarly, heavier applications of lime are needed on soils high in organic matter than on soils low in that constituent, provided the degree of acidity is the same in the two instances.

It is generally desirable to determine, in advance of application, the amounts of lime that are needed on the different soil types which comprise a field. Samples can be selected to represent the different soil conditions in a field and the lime requirement of each determined. Soil samples can be tested for acidity by the county agricultural agent or they can be sent to the Soils Subsection of the Iowa Agricultural Experiment Station. Applications of limestone should then be made according to the quantities indicated as necessary to neutralize acidity in the different parts of the field. Tests of samples may indicate that the soil in some part of a field is not acid, and no application should be made in such areas. The addition of lime does not benefit crops unless the soil is acid in reaction.

MAINTAINING ORGANIC MATTER

The amounts and nature of organic matter in the soil are important for a number of reasons. Organic matter serves as a storehouse for the nitrogen needed by growing plants; it also contains considerable quantities of phosphorus and smaller amounts of the other mineral elements necessary for plant growth. It serves as an energy source for microorganisms, and some forms of organic matter have a marked beneficial effect upon the physical condition of the soil (structure, porosity, permeability, etc.).

Many of the soils in Marion County, especially those with dark-colored surface horizons of intermediate to heavy texture, contained large quantities of organic matter when they were first plowed. These soils still contain large amounts of organic matter and humus, though there has been a tendency toward a gradual decrease since the region was first settled. When Prairie soils are brought into cultivation for the first time, the amount of organic matter in the upper layers of the profile tends to drop off for a period of years. Similar tendencies have been observed in other soils. The quantity of organic matter in the soil may thus be reduced below the amount necessary for highest crop production. Decreases in the content of organic matter generally reduce crop yields on sandy soil types and on the light-colored or Gray-Brown Podzolic soils more quickly than it affects the productivity of Prairie soils. The light-colored and sandy soil types originally contain smaller quantities of organic matter in their profiles, and a relatively small decrease may therefore have a more marked effect on crop yields. Steps to maintain or even increase the organic matter are necessary among the lighter-colored and the sandy soils of Marion County, but they are also desirable on most of the dark-colored soils.

Organic matter can be added to the soil by the plowing under of crop residues, the application of barnyard manure, the use of green manure crops and the growing of grasses in the rotation. All of these different methods of adding organic matter to the soil may find application on a single farm, but most farmers will find one method more useful than another. Practices to maintain the content of organic matter in the soil must be adapted to fit the needs of each farm unit.

The plowing under of crop residues will not maintain the content of organic matter at desirable levels in the soils of Marion County. It will, however, help to keep an adequate supply of humus in the soil, so that care should be taken to save and utilize crop residues. Practices such as the burning of cornstalks, for example, are not desirable except where insect pest or diseases are present. Since the plowing under of crop residues will not maintain the content of organic matter in the soil, the additional use of barnyard manure, green manure crops or grasses is necessary.

Barnyard manure is one of the most valuable forms in which organic matter can be added to soils. It supplies larger quantities of nitrogen than do most other kinds of organic matter generally available, and it has a number of beneficial effects that are not completely understood. Where considerable quantities of manure are available, as on a livestock farm, the supply of organic matter in the soils of that farm can be maintained by the conservation and proper use of that manure. It may and often does happen that manure is not well handled and thus loses much of its value before it can be applied to the land. The use of large quantities of bedding to absorb the urine, the storage of manure where it will be kept wet but will not be exposed to leaching by rainwater, and plowing it under as soon as possible after spreading are precautions that should be followed if maximum benefits are to be obtained. The value of barnyard manure as reflected in crop yields is clearly indicated in the results from the field experiments given in the tables in the preceding section of the report.

Sufficient quantities of manure to permit necessary applications on all fields are not produced on all livestock farms, and even smaller amounts are available on cash grain farms where fewer animals are kept. The growing of green manure crops and grasses to supplement the organic matter returned in crop residues and manure is generally necessary on such farms. Green manure crops have been used as a means of adding organic matter to a much greater extent than grasses in Marion County in the past. Legumes, which obtain a large proportion of their nitrogen from the air when they are well inoculated and thrifty, are perhaps the best green manure crops for general use, although other crops may be more desirable in special cases. The growing and plowing under of sweet clover or other legumes is a very desirable method of maintaining the content of organic matter in the soil on farms which do not keep large numbers of livestock. Additions of lime to most of the soils in Marion County are necessary for the successful growing of sweet clover, but the crop is especially valuable on soil types such as Chariton silt loam and Putnam silt loam.

The use of grasses in the rotation has not been as widespread as seems desirable in the general region of the Corn Belt. Close-growing crops such as the grasses and legumes, particularly the former with their fibrous root systems well distributed through the upper part of the soil mass, help to maintain the quantities of organic matter in the soil without being plowed under. Such crops also seem to have beneficial effects upon the structure of the soil, making it more porous and providing better aeration and water absorption.

As has already been suggested, further additions of organic matter would benefit crops on most of the soils in Marion County at the present time. Such additions, whether made as barnyard manure or in other forms, are more necessary on the light-colored and the sandy soil types than on the dark-colored ones, particularly the ones with imperfect drainage. Soils such as Muscatine silt loam and Bremer silt loam contain large quantities of organic matter and nitrogen at the present time; further applications in the form of barnyard manure would increase the possibility of lodging of small grains without compensating benefits to other crops. The growing of green manure crops and grasses, particularly deep-rooted ones such as sweet clover, is a desirable method of maintaining organic matter supplies in the dark-colored, imperfectly drained soils, and such practices will also help to improve their physical condition. Applications of manure will be especially valuable on the light-colored soils, the sandier ones and two members of the imperfectly drained group, Chariton silt loam and Putnam silt loam. The amount of barnyard manure available on many of the farms in Marion County will not be adequate to cover all fields, and it should therefore be utilized wherever it will be most valuable on each individual farm. Its use on the lighter-colored and sandier soils or on the well-drained, dark-colored types will generally bring better returns than applications to the imperfectly drained soil types. The well-drained, dark-colored soils are intermediate in their contents of organic matter between the light-colored group and those which have restricted drainage. In general, crops grown on the well-drained, dark-colored soils will be benefited by applications of organic matter, whether added in the form of manure, green manure, or by the growing of grasses.

Special emphasis should be given to the importance of further applications of organic matter on the light-colored and the sandy soils. Types such as Weller silt loam, Clinton silt loam, Clinton fine sandy loam or Tama fine sandy loam are all somewhat lower in their contents of organic matter than are the dark-colored soil types with heavier-textured surface horizons. Additions of organic matter in some form would therefore be especially beneficial to crops, as is indicated by the increased yields following applications of manure on Clinton silt loam (table 9).

TILLAGE AND EROSION CONTROL

Questions of tillage and erosion control will be discussed together, since the two are rather closely related. Land which is not being tilled or cultivated, other conditions being equal, is less susceptible to accelerated or harmful erosion. Some problems of tillage, of course, are not related to those of erosion control because of conditions of soil or relief which make special precautions for the prevention of erosion unnecessary. Similarly, problems of erosion may arise in regions which are not being cultivated, but these are of limited importance in Marion County. Questions of erosion control are not wholly limited to arable lands in Marion County, but those in cultivated fields are certainly more important for the region as a whole.

Problems of tillage which are not related to erosion control occur chiefly among the heavy-textured soils with imperfect drainage. These soils occur on smooth or nearly flat uplands, on terraces and in the bottomlands where the relief is such that harmful erosion does not occur. Care must be exercised in the cultivation of these soils, however, in order to keep them in a favorable physical condition. Soil types such as Muscatine silt loam, Bremer silty clay loam or Wabash silty clay loam can be handled satisfactorily only under a relatively narrow range of moisture conditions. If they are plowed either when they are too wet or too dry, the surface will be covered with hard clods which cannot be easily reduced to prepare a good seedbed. Many of these heavy-textured soils on flat topography should be plowed in the fall so that freezing and thawing may act on the soil to improve its structure. Varying the depth of plowing from time to time is also desirable so as to avoid the formation of a "plow sole," a compact layer immediately below the furrow slice.

The need for controlling harmful erosion exists to varying degrees on approximately two-thirds of the soils of Marion County. Slightly less than one-third of the county area, 32.2 percent, consists of nearly level lands where erosion is negligible because of the slight relief. Soils of the flat upland divides, the smooth terraces and the bottomlands fall in this class. Additional areas in which harmful erosion is negligible may be found in gently rolling lands which have been carefully farmed or used for pasture. Varying amounts of erosion have occurred, however, on many of the sloping and more rolling lands which are under cultivation. A number of areas which have been farmed, especially in the more rolling sections, have been affected to some extent by sheet erosion, and others, less widely distributed, have been seriously damaged by sheet and gully erosion. Most of the harmful erosion which occurs in Marion County is due to the action of water rather than wind, and it is more widely occurring on the light-colored than on the dark-colored soil types. Problems of controlling harmful erosion are more common on areas of Clinton silt loam, Weller silt loam and Lindley silt loam, for example, than on soils such as Tama silt loam or Muscatine silt loam, slope phase. Areas of the latter soil types have been damaged by erosion in a number of places, however. Damage from wind erosion is limited to the sandy soils in Marion County. Prevention of blowing on the sandier soil types requires such measures as the maintaining of rough, cloddy surfaces when plowing, the scattering of coarse residues over the field and the use of long-time rotations.

Methods of erosion control, other than engineering measures, are chiefly those practices which can be considered elements of good farming in the particular region. The selection and proper use of rotations, the application of manure or other forms of organic matter, the addition of lime or fertilizers when needed, are all practices for maintaining the fertility and productivity of the land; they are also essential in the control of harmful erosion. Where soils are well farmed, they are less susceptible to damage from erosion. Vegetative cover is denser when crops occupy the land because of the more vigorous growth of plants on fertile soils, and the soil itself is generally more permeable to rainfall and less readily moved by wind or water. Where sloping lands are not well farmed or are used improperly, harmful erosion is much more probable and commonly does occur. Such areas will then ordinarily require supplementary measures to control erosion and to improve their productivity. Some of the important supplementary practices in the control of harmful erosion due to water will be considered briefly in the following paragraphs.

The need for a soil management program to maintain fertility and favorable soil structure has already been stressed in earlier discussions in this report, but it might be well to re-emphasize the importance of proper rotations. On farms which consist of lands readily subject to harmful erosion, rotations followed should include more grasses and legumes, less corn and other intertilled crops. Smoother lands occupied by more fertile soils can produce a larger proportion of intertilled crops and do not need to be seeded down as often as do the more rolling lands. Areas which have been badly eroded may need to be retired from cultivation entirely and planted to grass or trees. These few examples are mentioned for the purpose of emphasizing the importance of the selection and proper use of rotations, both from the standpoint of maintaining fertility and of preventing harmful erosion.

In a region such as Marion County where the land surface is generally rolling and there is a well-developed network of drainageways, measures such as the seeding down of waterways, contour cultivation and strip cropping are helpful in the control of harmful erosion. The seeding down of waterways to grass is particularly important, since deep gullies requiring structures for their control most often develop in drainageways. Strips of grass along the drainageways in a field do not interfere with most cultivating, planting or harvesting operations. They do involve some extra trouble in plowing and the like, but it is far more convenient to maintain a waterway in grass than it is to control or reclaim a gully.

Cultivation on the contour is the practice of plowing, planting and cultivating along the slope so as to stay at the same level. A contour line is one which lies at the same elevation throughout its course, and the practice of farming sloping lands on the contour helps to minimize runoff and erosion. Contour cultivation is best adapted to rolling and gently rolling lands with a well-developed drainage pattern. It does not work as well in a region of youthful topography where the network of streams is incomplete. Long, unbroken slopes which are part of a system of distinct ridges and valleys generally lend themselves well to contour cultivation.

Strip cropping, as its name indicates, means the planting of crops in strips of varying but suitable widths. In regions where strip cropping is used as an aid in the control of water erosion, the strips are planted on the contour or across the slope of the land. Where wind erosion is to be controlled, the strips are planted crosswise to the prevailing winds. The proper arrangement and width of strips depend upon the nature of the topography, the type of soil and the crops being grown. Alternate strips usually consist of a close-growing crop such as alfalfa, grass or small grain and an intertilled crop such as corn. The establishment of a system of strip cropping generally requires that field boundaries be changed and that fences be relocated. When these changes are made, it is often desirable to eliminate steeper areas and badly eroded spots from the cultivated field, if possible, and plant them to grass or trees.

Terraces may be used to advantage on some of the fields in Marion County, but the building of such structures tends to be costly and should be considered carefully before it is undertaken. The type of terrace most commonly used consists of a broad, gently-rounded ridge which follows the contour rather closely and which has a shallow channel along the upper side. This channel serves to carry runoff waters around the slope to a protected, grassed drainageway which can then transfer it to lower levels without damage to the slope. Terraces should be considered supplementary means of controlling harmful erosion in Marion County and should be used only in conjunction with practices which are basic to the maintenance of soil productivity. They cannot be expected to take the place of such measures as crop rotations, additions of organic matter and liming.

There are a number of fields in the more rolling lands of Marion County in which gullies have been formed. These gullies, which range in depth from a few inches up to 8 or 10 feet, have developed along drainageways, old wagon trails and in various other places. The deeper gullies are usually found along drainageways and the shallower ones on the slopes in the upland. Gullies less than 2 feet deep can often be controlled by changing cultural practices and do not as a rule require structures. In some instances, temporary check dams made with sod strips, woven wire, brush or sod bags may be needed, and these dams can also be utilized in some of the deeper gullies. The sloping down and seeding of gully banks and the planting of trees are very effective in preventing further cutting in shallow gullies. Where large gullies have been formed, large permanent structures are needed to prevent their further growth. Permanent dams, whether of concrete or of earth, are expensive, and gullies should be controlled before such structures are necessary, if at all possible. Various types of dams suitable for the control of gullies are illustrated in Iowa Engineering Experiment Station Bulletin 121.

Summarizing briefly, the important measures in the control of soil erosion constitute good farming from the long-time point of view. Measures such as the use of the smoother and more permeable soils for cultivated crops and the rolling or hilly lands for pasture and forest are part of good farming practice which aids in the control of erosion. Applications of manure, the use of lime and fertilizer and good crop rotations are necessary measures to maintain soil fertility in this region. They are also basic in the control of soil erosion.

DRAINAGE

The natural drainage system of Marion County is well developed (fig. 2) and extends into all parts of the area. The larger streams have a branching pattern of tributary drainageways which have penetrated and dissected almost all of the upland. Areas of flat upland, as much as 1 mile wide, do exist in a few places in the county, and there are many narrower interstream divides. Such divides are occupied by Grundy silt loam and Muscatine silt loam, and these soil types commonly lack adequate natural drainage. Other soil types which are imperfectly drained occur on the flat terraces and in the bottomlands. All together, the soils which lack adequate natural drainage occupy approximately one-fourth of the land in Marion County. Soils with inadequate drainage in the uplands and on terraces are Grundy silt loam, Muscatine silt loam, Putnam silt loam, Chariton silt loam, Bremer silt loam and Bremer silty clay loam. Wabash silty clay loam, some areas of Wabash silt loam and Cass silty clay loam of the floodplains are also imperfectly drained. All of the soils in the bottomlands are subject to overflow when streams are in flood, and the water table tends to remain near the surface along the permanent streams. Crop production is increased on all of the imperfectly drained soils by the improvement of drainage.

Tile drains and ditches have both been used to carry away surplus water from the imperfectly drained soils of Marion County. Tile drains have been used more commonly in Muscatine silt loam than in any of the other soils, since they operate more effectively in that soil type. The deeper horizons of the profile are not as compact or as heavy in texture as are those of the Grundy and Bremer soils, thus permitting the tile to draw over greater distances. Tile drains have been used with some degree of success in areas of Grundy silt loam and Bremer silt loam, but they are seldom satisfactory in the Chariton or Putnam soils because of the very heavy claypan horizons in the latter soils. Open ditches are used more generally, and usually more effectively, in the removal of surplus water from the Putnam, Chariton, Bremer and Grundy soils or in draining the soils in the floodplains. In some of the fields where tile drains have been in operation for a long period of time, they have gradually become less effective. Two, and possibly more, factors contribute to the decreased efficiency of the tile. The tile drains in some places have become partially filled with silt and clay, and they must be dug up and cleaned before they will operate as they once did. Another factor which influences artificial drainage over wide areas is the gradual deterioration of the original granular structure and the decrease in permeability of the soil mass. The breaking down of soil structure is most pronounced where the land has been used for the continuous or repeated production of corn. The inclusion of more close-growing crops, such as grasses, in the rotation and the use of deep-rooted legumes such as sweet clover, will help to improve the structure of the soils in such fields. The growing of deep-rooted crops, such as sweet clover, will be beneficial on the Putnam and Chariton soils, because it will tend to improve the permeability of the dense and compact claypan horizons.

Drainage districts have been established along some of the larger streams such as the Skunk River and Whitebreast Creek. Parts of the channels of both of those streams have been straightened and dredged out so that runoff waters drain away more rapidly. Shallow surface ditches have also been dug in some places in the bottoms to facilitate drainage. Improvement of drainage is generally more difficult and less feasible within the floodplains of the streams than it is in the uplands or terraces.

Artificial drainage is expensive, but it is necessary if some lands are to be cultivated successfully. Before lands are drained artificially, however, it should be certain that their productivity after drainage will warrant the original cost. In large-scale drainage operations such as the straightening and deepening of stream channels, consideration should be given to the possible effects of such drainage on flood hazards downstream.

USE OF COMMERCIAL FERTILIZERS

Nitrogen, phosphorus and potassium are the principal elements which are available, either singly or in combination, in commercial fertilizers. These three elements are used rather heavily in crop production and often become deficient in the soils of humid regions. Wherever deficiencies occur, both the total yield and the quality of crops are affected. Deficiency of any element must be overcome largely by additions of that element in some form of fertilizer material. Nitrogen can be added to the soil in large quantities in manure, as commercial fertilizer or by the growing and plowing under of green manure crops. Phosphorus and potassium also can be applied in large amounts as commercial fertilizers, and they are present in appreciable quantities in manure. Up to the present time only limited quantities of commercial fertilizers have been used in Marion County. Phosphorus and potassium, where used, have been applied to special crops almost entirely, and the nitrogen returned to the soil has been derived largely from barnyard manure and green manure crops.

Among the various soils of Marion County, those which have dark-colored surface layers with intermediate or heavy textures contain relatively large amounts of nitrogen and phosphorus. The light-colored soil types generally contain less nitrogen and somewhat smaller amounts of phosphorus, though the differences are less marked in case of the latter element. All of the soils of the county except the sandy ones contain relatively large amounts of potassium. Sandy soils almost invariably contain smaller quantities of all of the elements necessary for plant growth than do those with loam or heavier textures.

Actual deficiencies of one or more of the three common fertilizer elements, considered from the standpoint of successful crop production, occur chiefly in the sandy and the light-colored soil types of Marion County. The better soil types in some fields may be deficient in one or more elements because of improper management, but as a general rule the lack of these elements is not the limiting factor in plant growth. In considering the better soil types in Marion County, however, it should be remembered that ample supplies of the essential nutrient elements must be present in the soil for the production of good crops of satisfactory quality.

Generally speaking, the nitrogen reserves in the soils of Marion County can be economically maintained by the proper use of manure and the growing and plowing under of legumes. The use of manure and the growing of certain legumes have beneficial effects upon the physical condition of the soil, in addition to supplying a number of plant nutrients among which nitrogen occurs in the largest quantity. The application of nitrogen in the form of commercial fertilizer would not seem to be necessary except as a side-dressing or top-dressing for special crops.

Phosphorous tends to promote the development of the root systems of plants and seems to hasten maturity. It perhaps affects the quality of the crops grown to as great an extent as the quantity obtained, and for that reason applications of the element would be beneficial on many of the soils of Marion County. Individual fields on some of the better soil types may, in some instances, have received heavy applications of manure so that the crops grown would not be improved by phosphate applications, but such fields are relatively few. Phosphorus can be applied to soils in a number of different fertilizers, of which rock phosphate, superphosphate and mixed fertilizers (mixtures usually contain superphosphate as the carrier of phosphorus) have been tried in the field experiments carried on by the Iowa Agricultural Experiment Station. Superphosphate and rock phosphate usually will be the more economical forms to apply for the common field crops grown in Marion County. Superphosphate contains a higher percentage of readily available phosphorus than does rock phosphate and, consequently, costs more per hundred pounds. It can, however, be applied in smaller quantities because of the higher concentration of soluble phosphorus. In the selection of phosphate fertilizer, the cost of the readily soluble phosphorus in each of rock phosphate and superphosphate should be considered as well as the nature of the soil and the types of crops to be grown.

The data presented in tables 5, 7, 8 and 9 seem to indicate that the response of small grains and legumes to applications of superphosphate are slightly greater than those to additions of rock phosphate. Definite superiority is not apparent with the small grains, however, and this is even more true with corn. Rock phosphate was applied in much larger amounts than superphosphate, the average application during a rotation being about three times that of the latter fertilizer. If hill or row applications are used, as for example in the fertilization of corn, phosphate should be applied in the more soluble form and in smaller quantities.

Potassium seems to be present in most of the soils in Marion County in sufficient quantities to satisfy the needs of crops for some time to come. Sandy soils are deficient in the element at the present time, and crops grown on those soils would be improved by applications of potash fertilizer. A slight response to muriate of potash is also indicated in the data for Clinton silt loam in table 8. General applications of potassium fertilizer for all field crops on the soils of Marion County does not, however, seem necessary at the present time.

APPENDIX

PURPOSE AND METHODS OF SOIL SURVEY[10]

The chief purpose of soil surveys is to provide accurate soil maps which can be used to help classify, interpret and apply data regarding agricultural production. In agronomic work, for example, it is not possible to carry out experiments on each different soil in every field in the state; trials can only be made on a limited number of fields. Consequently, there must be some way in which the information obtained from experiments and experience on a given area of a certain soil can be extended to other areas of similar soils. Such means exist when the different kinds of soils and their locations are known; accurate soil maps and descriptions provide this type of information.

Soil maps, if they are to serve their purpose, must show the location and extent of the different kinds of soil with sufficient detail and enough precision to indicate those differences that are important to man in using the land for the growth of plants. Since the number of important differences in soils is not identical in all landscapes, maps vary as to the detail which is represented. Obviously a map of an irrigation project will have to be much more detailed than will one of grazing country; smaller areas of land and smaller differences in the nature of the soil will have profound effects upon the success or failure of farmers in an irrigation project. The soil map should indicate all important differences, if it is to be as useful as possible. Briefly, the chief function of a soil map is to help us classify, remember and extend our knowledge regarding the use-suitabilities of dif-

[10] For a more complete discussion of soil survey purposes and methods, see Kellogg, C. E. Soil Survey Manual, U. S. Dept. Agr., Misc. Pub. 274. 1937.

ferent kinds of soil. In addition to providing a basis for the classification of information gained from experience and experiments with soil, a soil map also provides an inventory of the soil resources after it has been completed. It is helpful in many cases to know the exact acreages of particular kinds of soil, but it is commonly more important to know the location and distribution pattern of soil types.

Soil maps are prepared by means of soil surveys which consist of the examination, classification and mapping of soils in the field. The maps are commonly made for areas of one county, but at times, parts of one or more counties may be selected, as for example, in irrigation projects or in demonstration watersheds.

The first step in the making of a soil survey of an area is the examination of its soils in a number of different locations. Test pits are dug, borings are made, and the soil is studied in available exposures such as road and railroad cuts. Descriptions are obtained of the soil profiles exposed, and samples are often collected for laboratory study. Each horizon of the soil profile, down to and including the parent material, is carefully described as to color, structure, texture, porosity, consistence and the presence of roots, gravel or stones. The reaction (degree of acidity) and the content of lime or other salts is noted in each of the different layers. The relief or lay-of-land and drainage, both internal (through the soil) and external (over its surface), are noted and described. Attention is also given to any observable relationships between the soil and the vegetation.

After the soils have been examined in a number of different locations, they are classified according to the observed characteristics, both internal and external, with special emphasis being given to those features which influence the adaption of the land for the growing of crop plants, grasses and trees. In the classification of soils in county areas, the most important group is the soil series. A series consists of those soils which have similar genetic horizons, alike in arrangement and important characteristics, and which have developed from a particular type of parent material. The soil profiles within a series consist of horizons that are essentially alike in color, thickness, arrangement, structure, etc. The texture of the upper part of the soil, corresponding to that part which is commonly plowed, may vary significantly within a series, thus giving rise to soil types. Except for the variation in texture in the surface layer, the soils within a series should be essentially alike both in internal and in such associated external characteristics as drainage and range in relief. Soil series are given place names selected from the geographic regions in which they were first identified and mapped; Tama, Shelby, Grundy and Clinton are names of important series in Marion County.

Soil types are subdivisions within a series, the separations being based on the texture of the surface layers. The name of each soil type consists of a combination of the series name with that of the class name of the soil texture (sand, sandy loam, loam, clay loam, silty clay, etc.). Thus, Clinton silt loam and Clinton fine sandy loam are two soil types within one soil series. Except for the differences in the texture of the upper soil layers, the profiles of the two soil types are approximately the same. The soil type is the principal unit used in mapping, and because of its specific character, it is usually the one to which agronomic data are definitely related.

At times, different areas of one soil type may differ in some characteristic that has important practical significance. Features not reflected in the character of the soil but highly important in cultivation, such as stoniness, relief or accelerated erosion, sometimes vary enough within one soil type so that portions are not well suited for cultivation while others are. Such variations are indicated as phases; for example, Muscatine silt loam, slope phase, has been mapped in Marion County to indicate areas of soil similar to Muscatine silt loam in general profile characteristics but differing from it in being found on sloping rather than level lands.

Mapping units called miscellaneous land types are occasionally used in preparing a soil map of a county. Riverwash, mountainous areas, rough and broken land, sand dunes and peat or muck are generally indicated as miscellaneous land types. A number of areas of Riverwash were mapped along the channels of the Des Moines and Skunk Rivers in Marion County.

After a legend has been prepared to indicate and describe the different units which are to be shown on the soil map, a suitable base map must be obtained or prepared before field work can progress. Aerial photographs constitute the most satisfactory base map and are used wherever they are available. Geological survey quadrangles are also good base maps. In a number of areas or parts of areas satisfactory base maps are not available, and the soil surveyor must prepare one. Base maps, after they have been obtained or prepared, should be carefully checked against the land survey, especially in sectionized regions.

When both the legend and the base map are ready, the boundaries of the different soil types, phases, etc., can be located and indicated on the map by means of symbols. In locating the boundaries of the mapping units, the surveyor traverses the landscape at intervals of ¼ mile, ½ mile or whatever interval will allow him to observe each boundary throughout its entire course. It is sometimes necessary to go out from the line of traverse to make sure of the location of a boundary, but it is seldom necessary to follow a boundary through its entire course to see where it is located. After the field sheets are completed, they show the location of the soils and miscellaneous land types with respect to houses, roads, railroads, streams, lakes, section and township lines and other natural and cultural features of landscape.

Field work in the soil survey of Iowa has been carried on cooperatively between the Bureau of Chemistry and Soils of the United States Department of Agriculture and the Soils Subsection of the Iowa Agricultural Experiment Station. After the field work is completed for an individual county, a colored map on a scale of 1 inch to the mile is prepared by the Bureau of Chemistry and Soils. An accompanying text to describe the soils, agriculture and other important features of the county area is also prepared, and this is published together with the colored map as a report of the survey.